FLIGHT and The AIRCRAFT ENGINEER

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The Outlook

The Altitude Complex

THERE was a time when the speed of fighters caught the public imagination to such an extent that all other attributes were overlooked. One result was the number of Spitfire funds which sprang up, not merely all over the country but overseas as well. That was all to the good, and the Spitfire fully deserved its publicity; but other types did not catch the imagination in the same way, although they had qualities which made them just as useful.

Lately there has been a tendency to swing over from speed to altitude. The Boeing "Flying Fortress," with its turbo-superchargers and operational height of more than 30,000ft., started the ball rolling. The idea that a large bomber could operate at altitudes barely attainable by fighters, and outside the range of most anti-aircraft guns, appealed to the non-technical mind. What was overlooked was the fact that, except on very rare occasions, when the atmosphere was uncommonly clear, precision bombing could not be expected.

It is rather interesting to find that no "national pride" seems to be involved. The American Boeing got more than its fair share of the limelight. But lately one has heard the criticism of more than one American fighter: "Oh, well, it is quite a good aircraft, but it has no ceiling." That is a very common remark which may be overheard in restaurants, on trains and buses, and in the street, yet it is rather pointless.

The "Flying Fortress" has made the public altitude conscious, and if an aircraft has a ceiling of no more than 15,000 to 20,000ft. it is condemned on that score. The man in the street cannot be expected to realise that not all war flying is done at great heights, nor that if an aircraft has an engine supercharged to give its maximum power at 20,000ft. it will be at a disadvantage at lower levels. The two-speed, two-stage supercharger will to some extent avoid this handicap, but even so there are operational requirements which call for medium-altitude as well as for high-ceiling fighters.

Examples have occurred frequently since the existence of the Hurricane fighter-bomber was disclosed. While the Hurricanes do their job almost at ground level, they are protected by an "umbrella" of high-flying Spitfires which have accounted for many enemy fighters that tried to attack the Hurricanes. In other classes of aircraft, too, operational considerations demand performance at medium heights no less than at great altitudes. It would be well to bear this fact in mind when trying to assess the value or otherwise of any particular aircraft type.

Stern Propellers

A CORRESPONDENT in this week's issue recalls that the fighter design published on November 27th is not actually new, so far as the placing of the airscrew is concerned. We have been able to corroborate this, and we publish a picture, reproduced from *Flight* of January 6th, 1912, of the Paulhan-Tatin *Torpille Aerienne* exhibited at the Paris Aero Show of 1911. The question arises whether it would be profitable to revive this unusual placing of the airscrew. Incidentally, we suggest that airscrews placed in the extreme stern are better termed stern propellers, this being a more convenient expression than stern airscrews.

Our correspondent has mentioned one or two advantages that might accrue by the adoption of this arrange-

ment. The remarkable view for flying and fighting is obvious. To that might be added the relative ease with which a really large cannon could be mounted in the nose. Loading would be within reach of the pilot, as well as the possibility of clearing a jamb.

It would be well, however, not to overlook the possible disadvantages of the stern-propeller aircraft. The tricycle undercarriage would probably have to be rather taller than usual, and possibly some form of tail skid would have to be fitted to protect the blades during a landing. Directional control might be a little less good, as there would be no slipstream (twisted or otherwise) to give extra speed of airflow over the rudders at low forward speeds. That, however, applies to any single-engined tractor aircraft with twin rudders outside the slipstream.

More important might be the placing of so heavy a weight in the extreme tail. In the old days of wooden airscrews the weight consideration was not so serious from the point of manœuvrability, but a large modern metal three-blader might be an unpleasant object to have swinging around so far from the centre of gravity. Finally, there is the loss of airscrew slipstream over the wing. This gives quite a considerable amount of extra lift, even when not applied Crouch-Bolas fashion, and the landing speed would probably go up as a result. Very careful consideration would have to be given to all the factors in order to decide whether or not the disadvantages would outweigh the advantages of stern propellers.

The Battle of Sidi Rezegh

THERE have been tremendous battles in Russia in which tanks and aircraft have been the dominant arms, but until the Empire forces started their advance in Libya on November 18th, British commanders, whether Generals or Air Marshals, had little or no experience of such engagements. All sorts of lessons will be learnt by both Services from the struggle which has been raging with Sidi Rezegh as its focal point. At first the British clearly held the upper hand in the air, and the R.A.F. with its Empire confederates will, we all devoutly hope, retain that supremacy until a decision has been reached. That has undoubtedly given our men a comparatively free hand in getting supplies and reinforcements up to the places where they were needed. It has also done much to restrict the enemy's supplies—which may prove decisive.

There are, however, certain things which we in Great Britain do not yet know, and which, perhaps, our leaders on the spot are only finding out by experience. We do not yet know, for example, the exact value to the enemy of transport aircraft. From this battle we all hope to learn a great deal more than we now know about the effectiveness of various descriptions of air attack on various categories of ground vehicles; for example, whether bombs or cannon shells are the best destroyers of light, medium or heavy tanks, and also of armoured cars; which calibre of shell and which weight of bomb does most harm to each of these classes of vehicle, and so on. Whether our 20 mm. shellguns are sufficiently devastating in their effect upon heavy tanks is a question upon which assurance would be comforting, and if this is not so, as we judge from published accounts from Libya, whether the necessary larger bore air cannon can be made available.

In addition, the Generals must be studying the tactics of the employment of the different classes of mechanical vehicle, which study, in its turn, may have its effect on the tactics of air support for an armoured force.

The Germans can draw on their experience in Russia, but this is the first battle of its sort fought by the British, and is, therefore, to some extent an indication of the lessons which have, or might have, been learned from other theatres of war.

STILL GOING STRONG: A recent picture of Wellingtons in formation. With the new Stirlings, Halifaxes and Manchesters in the limelight it should not be forgotten that the Wellingtons, Whitleys and Hampdens still carry the major part of our night offensive.

War in the Air

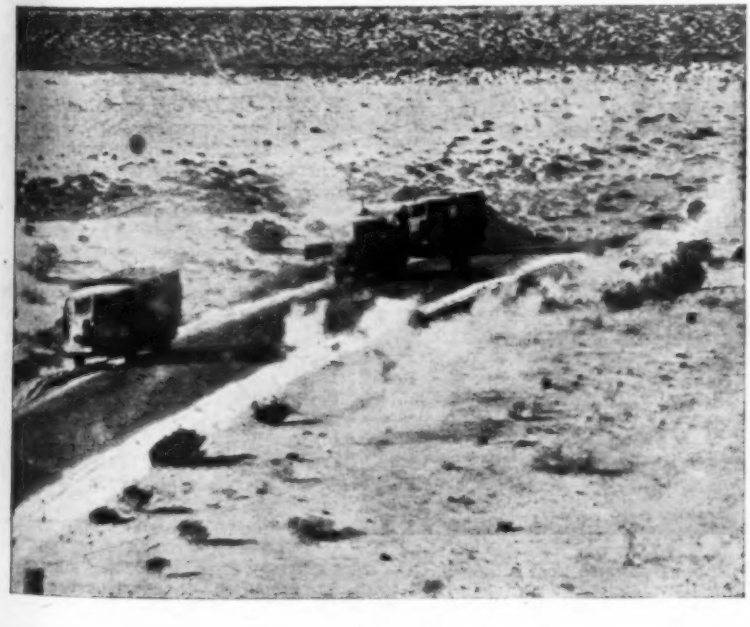
STAR PERFORMERS: Russian I.16 fighters in Vee formation.

Libyan Battle Rages on : British Air Superiority : The Problem of Supply : Brest Raided Again

SO far as can be judged from the rather scrappy reports of the battle in Libya, one of the outstanding facts seems to be that the British air forces have a very valuable supremacy in the air. In the first six days of the fighting they destroyed for certain 119 of the Axis aircraft, and they must have damaged many others. They have done this at very small cost to themselves. On Monday, November 24th, for instance, the Middle East Command did not lose a single machine, although the squadrons ranged far and wide over the whole battle area and beyond it up to Berka and Benina, the airfields south and east of Benghazi, in addition to helping the Indian troops to capture the oasis of Jalo far to the south of Cyrene.

The enemy, as one would expect, has been desperately hurrying reinforcements of air squadrons across from Sicily and bases in Europe, and the air fighting has been growing fiercer. None the less, when the Germans took the bold, but rather desperate, move of detaching a force of tanks from the main battle and sending it eastwards across the Egyptian frontier, they do not seem, so far as has yet been reported, to have sent any air support with it. It was not unnatural that this move came as a surprise to the British commanders, but the surprise might have been very much more effective if the R.A.F. had not spotted the enemy column in good time. Of course, our aircraft reported its movement and whereabouts to the appropriate army headquarters, and at the same time attacked it with bombs and machine-gun fire. They inflicted heavy losses upon it, and General Cunningham did not find it necessary to detach any of his forces from the main battle to pursue these enterprising tanks. Other British forces were speedily organised to deal with the remnants of the column.

After the confused tank battle had raged furiously for the best part of a week both sides began to slacken off, as a result of casualties to the tanks and other vehicles, and from the sheer exhaustion of the men engaged. There were two days which were described as "simmering." Then both sides began to introduce reinforcements. One was sure without being told that such a gifted commander as General Cunningham would have reinforcements in hand, which he would not throw into the mêlée until he thought that the moment was ripe. But one wonders what strength of reinforcements the enemy can bring up. The Germans and Italians must have had some extra tank units at Benghazi and Tripoli, but certainly not so many as they would have liked, for the Navy with its Air Arm and the R.A.F. have been sinking many of the supply ships in the Mediterranean, as well as bombing the ports of sailing (mainly Naples and Brindisi) and the ports of arrival in Africa. It can be no easy matter to get those reinforcements up to the battle area in the teeth of superior air power, and the British aircraft have undoubtedly been top dogs.



TRANSPORT PROBLEM: Air attack by the R.A.F. on enemy columns on the Agheila-Agedabia road in Libya. This is one of the main supply roads south of Benghazi.

WAR IN THE AIR

It may well happen that in the end the battle will be decided by the question of supply. The amount of petrol and oil which has been consumed by the fighting vehicles since the battle started must have been simply appalling, but from all accounts the British have been getting their fuel, their ammunition, and their water and food without serious interruption. On the other hand, our bombers and fighters have been making havoc of the enemy's supply columns, and in every report one reads of tankers set ablaze, and lorries and other vehicles shot to pieces from the air. Of course, some supplies get through, and of these a proportion probably goes by transport aircraft, some of which may tow gliders filled with supplies. When spotted these Junkers 52 machines are an easy prey for our fighters, but the latter cannot be everywhere.

ALL SET: A Russian bomber crew check up on their "briefing" instructions before take-off. Their flying equipment seems to be of good quality.

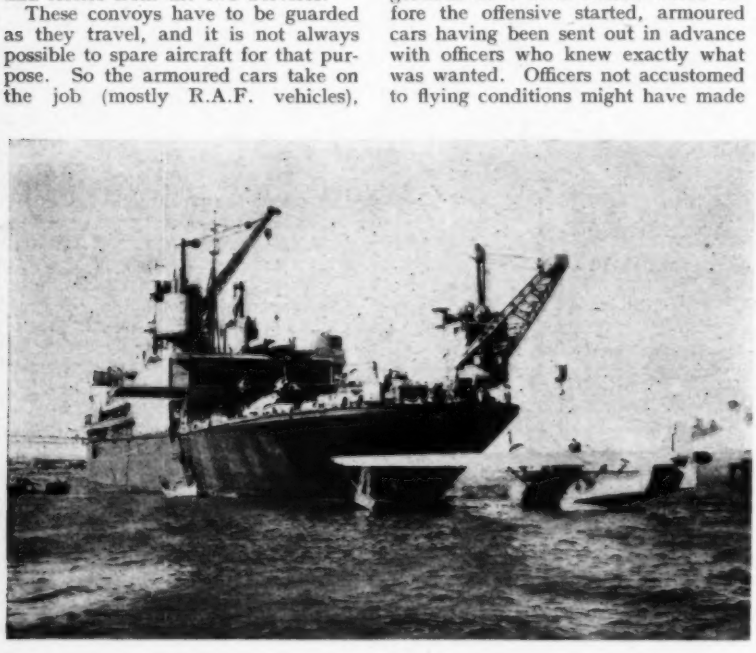
Supplying the Squadrons

THE Empire air squadrons also need large quantities of petrol and other supplies. A squadron making several sorties a day will use between 3,000 and 4,000 gallons. The squadrons have to change their landing grounds as the battle sways backwards and forwards, and the task of the men who have to get the supplies up is no sinecure. The Royal Army Service Corps is working with the Royal Air Force, and a convoy for one squadron has often been composed of tankers and lorries from the two Services.

These convoys have to be guarded as they travel, and it is not always possible to spare aircraft for that purpose. So the armoured cars take on the job (mostly R.A.F. vehicles), though here, too, the Army must frequently lend a hand. The R.A.F. armoured cars do not often get into the limelight, but they are a very useful branch of their Service, especially in desert warfare. The crews have gained most of their experience in Iraq, and so desert conditions are nothing new to them.

Clay pans dot the Libyan desert, and they provide an excellent surface for landing and taking off, when their area is sufficient. Such landing grounds have been chosen weeks before the offensive started, armoured cars having been sent out in advance with officers who knew exactly what was wanted. Officers not accustomed to flying conditions might have made mistakes in their choice, and it is a very good thing that the R.A.F. has its own organisation for this work.

When a squadron has to move to one of these chosen sites, the transport goes on ahead, and may sometimes have to drive for ten hours over rough ground to reach it. The armoured cars go first, followed by anti-aircraft batteries and Lewis guns. Then comes the mobile operations room, and with it the lorries with the necessary stores. The movement is so timed that the ground arrangements are in order by the time the aircraft arrive, and when they land the aircrews find a meal of hot tea, bully beef, and biscuits ready for them. One feels certain that many units of the Axis forces do not fare so well as that when night falls.



FLOATING BASE: Consolidated Catalinas being operated from a U.S. seaplane carrier.

Other Fronts

NATURALLY this great battle in the Libyan desert almost monopolises the interest of British readers; but elsewhere the war goes on as fiercely as ever. Moscow is certainly in danger as these words are written, but even if the Germans capture it they may find that they have lost more than they have gained. They are sacrificing men and material at a fantastic rate, but if the Russians can keep on fighting *after* the loss (if that occurs) of their Capital, it would certainly seem that Hitler's bolt will have been shot. For the moment, however, there is not much news of important air operations in Russia, though doubtless there is much bombing and counter-bombing which is not reported in the communiqués.

Likewise the R.A.F. Commands in Great Britain have been carrying on their regular offensive, as the weather has permitted—though on several days

BLITZ SPECIALIST: General Loerzer, one of the *Luftwaffe* High Command on the Russian front.

and nights of late sorties have not been possible. Brest has had more than one visit, and we hope that the bombs dropped have retarded repair work on the German warships. R.A.F. offensive fighters have attacked useful targets in France, and the Coastal Command has scored several more successes against the enemy's shipping.

The Fall of Gondar

FOR quite a long time now the Italian power in Abyssinia has ceased to be of any account, but one considerable force continued to hold out at Gondar, to the north of Lake Tsana. During the bad weather the British commanders were content to leave this force to its own devices, merely blockading it and cutting off supplies from outside. Towards the end of November the place was seriously tackled, but most of the preparatory work was entrusted to bombers of the South African and Royal Air Forces. The assaulting troops who followed on were nearly all Africans of different races, Ethiopian Patriots and regiments of East and West Africans in the British service. They fought as gallantly as could be desired, and the bombers made their task comparatively inexpensive. It was, in fact, economical warfare; and this was well, for most of our white troops and Indians were busily engaged in the Libyan battle or elsewhere in the Middle East. The Italian garrison seems to have made one final stand with no little gallantry, but there was really no point in these men all dying in the last ditch. So the white flag went up over Gondar, and the Italian commander surrendered unconditionally. Without air supremacy on our side, this operation might have cost us far more lives and time than it actually has done. Abyssinia is now completely cleared.

Another satisfactory event has been Marshal Timoshenko's recapture of Rotov-on-Don. We have not heard much about the air side of this very considerable Russian success, but it is believed that our Ally had massed a large air force there. In modern warfare success can hardly be gained without some degree of superiority in the air. The German thrust in the extreme south of Russia was probably the most menacing of all their efforts, and might have had a very serious effect on the campaigning next spring. Even the sieges of Moscow and Leningrad were probably of less importance than the road to the Caucasus.

As we go to press, the battle of Sidi Rezegh goes slowly but steadily in our favour. The heavy German tanks in the centre of the battle are proving a hard nut to crack, for they seem able to withstand attacks by lighter British tanks, and also to be impervious to bombing and cannonading from the air. General Rommel has evidently given up hope of a positive victory, and has been concentrating on an effort to get his main force away to the west. So far he has been unable to do so. Lighter tanks, both German and Italian, and especially transport vehicles, are not so immune from air attack, and our heavily armed Beaufighters and other aircraft have wrought immense damage among them.

ENEMY AIR LOSSES TO NOV. 29th.

	Over G.B.	Over Continent	Middle East
Nov. 23	2	0	(?)
" 24	1	1	8
" 25	1	1	10
" 26	1	0	2
" 27	0	2	10
" 28	1	0	3
" 29	0	0	2
	6	4	35

Totals: North, 5,567; over 2,302. Middle East.

Reports from Middle East have been rather confusing.

BRITISH AIR LOSSES TO NOV. 29th.

	Over G.B. A'crft.	Over Continent B'brs.	Ftrs.	Pilots	Middle East A'crft.
Nov. 23	0	1	7	6	13
" 24	0	2	0	0	0
" 25	0	1	0	0	5
" 26	0	1	0	0	5
" 27	0	1	3	3	4
" 28	0	0	0	0	7
" 29	0	0	0	0	0
	0	6	10	9	34

Totals: North, 3,028; Middle East, about 546.

JACK O'BOTH SIDES: A short-nosed Blenheim being hauled on to a Finnish airfield on the Northern Front. It is one of a number supplied to Finland for their previous war with Russia in 1939.

Topics of the Day

LESS GLAMOUR

A Word of Praise for the Bomber Crews and Other Rarely Considered People in This War

ONE gathers from "unimpeachable" sources that in the Reich the men who are given the nearest possible approach to a whale of a time are the *Luftwaffe* flying crews and the Panzer boys. Apparently they can—or could—get away with murder (paradoxically speaking) and have the run of things in the big cities. Whether true or not, that is the sort of thing one would have expected in a country where every man, woman and child must, it seems, have a little tin god to fuss around.

Here we don't do things that way, and in any case we all know quite well that the A.F.S. and Wardens and people of that kind face greater dangers in the big cities during a bad blitz than even the fighter pilots and bomber crews. And they proceed about their normal business with nothing but a little badge to show the world in general that they are warriors.

Perhaps the fighter pilots—more usually, I believe, known as Glamour Boys (or perhaps that is a "dated" expression)—came nearer to being treated as popular heroes than any other section of the community. Of course, they were and are heroes (just as nearly everyone else is when it comes to the pinch), and the general public were not unnaturally impressed by the terrific performance of the quite surprisingly few during the daylight attack period last year. When this war is over we shall learn just how nearly the Germans came to breaking up, by sheer weight of numbers, the fighter squadrons whose job, morning, noon and night, was to hold them off.

And the fighter pilots of those days, even more so than in 1941, were the flower of flying manhood—auxiliaries and volunteer reservists who had been flying in their own time for months before the war. Not that they didn't fly because they loved it—there can have been few who really thought there would be a war or who did not join the A.A.F. or the V.R. because of the chance of learning to fly properly, of flying nearly as much as they liked, and of doing it for nothing. Let us not have any false ideas. But it was difficult to get by in those days, and the regular R.A.F., A.A.F., and R.A.F.V.R. pilots who made up the defence squadrons were undoubtedly the pick. No conscripts—if there are such people nowadays—could have done the job as well, or even at all.

Real Courage

Now it is *our* turn to attack, and if heroes must be invented, let us hand the bouquets to the bomber crews. It takes more plain, unassisted courage to fly for five hours by day or by night over enemy territory than it does to make a dashing patrol of a couple of hours' duration—with the hope, all the time, that some excitement will be forthcoming. The fighter pilot is busy, he has his life in his own hands, he has a machine which is the last word in offensive capacity. If his temperament is of the right kind he actually enjoys pitting his wits and flying skill against an enemy's. That sounds pretty bad in cold print—the sort of thing written for schoolboy magazines. But it is so.

The bomber pilot leaves his base at the time of day when most people have ceased to take any further part in the uneven struggle. He flies an often overloaded machine which, in any case, is far from manœuvrable. Whatever the *flak* situation he must make several straight runs over his target. And he must get the outfit back—very often in a bad state of disrepair and to a country which has developed a brand-new set of weather conditions.

His crew just sit tight and hope for the best, the radio operator reading a book in the intervals, and the gunners sitting in their dashed uncomfortable and soulless turrets driven by hydraulic oil. The gunners are lucky if they get a crack at anything, and if the "Abandon aircraft" order is given—well, have you ever seen the little hole through which they are expected to get themselves and their pack? And the rear gunner, in particular, is as lonely as anyone can be—and still more lonely if the inter-com. breaks down.

Ask anyone which he would rather be, a fighter pilot or one of a bomber crew, and I can almost guarantee the answer. Of course, everyone isn't fitted to be a fighter pilot, or even a pilot of any kind, and most people would rather fly in a bomber than not fly at all. But I think it is time that the bomber crews were given their headlines—if, as I say, headlines have to be given. With so many people doing so many hazardous jobs without a trace of limelight, I see no reason why there should be any headlines at all.

Natural Fear

Nothing is ever quite as bad in fact as it is in prospect. That is a dull and commonplace remark, and it doesn't seem to help very much. For years I've been frightened to death of things, and I've always found that there was really nothing very much to be frightened of when it came to the point—except, perhaps, making a speech. On the few occasions when I really have been in a tight corner, fear has been the only absent emotion. The whole body, with its glands and things, is organised to deal with such situations. Something or other is poured into the blood to make you quicker-witted than ever before, and to leave your mind absolutely calm. People who run away usually do it before the event and not during it—and the temptation to run is often almost irresistible. That, again, is the body playing its correct part. The wretched thing wishes to be preserved; the simplest form of self-preservation is non-participation, but once it has been dragged in and there is no escape, it organises itself immediately to deal with the new situation.

Headlines or no headlines, I feel that the fighting and other "true" Services should be given more chance to enjoy themselves when on leave. Not for any beautifully altruistic motive, but because good leaves make good workers. I'm thinking at the moment of the pilots and others who are doomed to rot slowly away at large soulless airfields miles from the nearest town. Many of them don't bother to take the leave to which they're entitled because there's nothing much to do, or because they have no petrol coupons or no car, or because the transport situation is too difficult. One gets so thoroughly sick of the sight of the ugly, cheap and cold buildings that make up a rapidly constructed R.A.F. station—which, in winter, can be a hell of minor discomfort. I believe that operational crews are given quite a few facilities, but the others just sit and hope for the best. It is difficult to maintain enthusiasm and morale in bad conditions *unless* there's something to look forward to. Leave, and something definite and pleasant to do on one's leave. I feel that such things are of immense importance when a war has to be won.

While we are thinking of the "also-rans" let us remember all those people who are doing other jobs for which no medals are offered or expected. The pilots who tow targets for others to shoot at, the pilots who make dull patrol flights over heaven knows how many miles of sea, the pilots who spend hours and days and weeks in the front seats of primary trainers, the pilots who test new types and other less new types which have been modified or rebuilt by personnel not considered good enough to go to squadrons, and the vast mass of men and women in the R.A.F. who do soulless administrative and other jobs without which the necessary machinery would break down. Floods of paper and floods of tears.

"INDICATOR."

MIDDLE EAST SUPPLY LINES

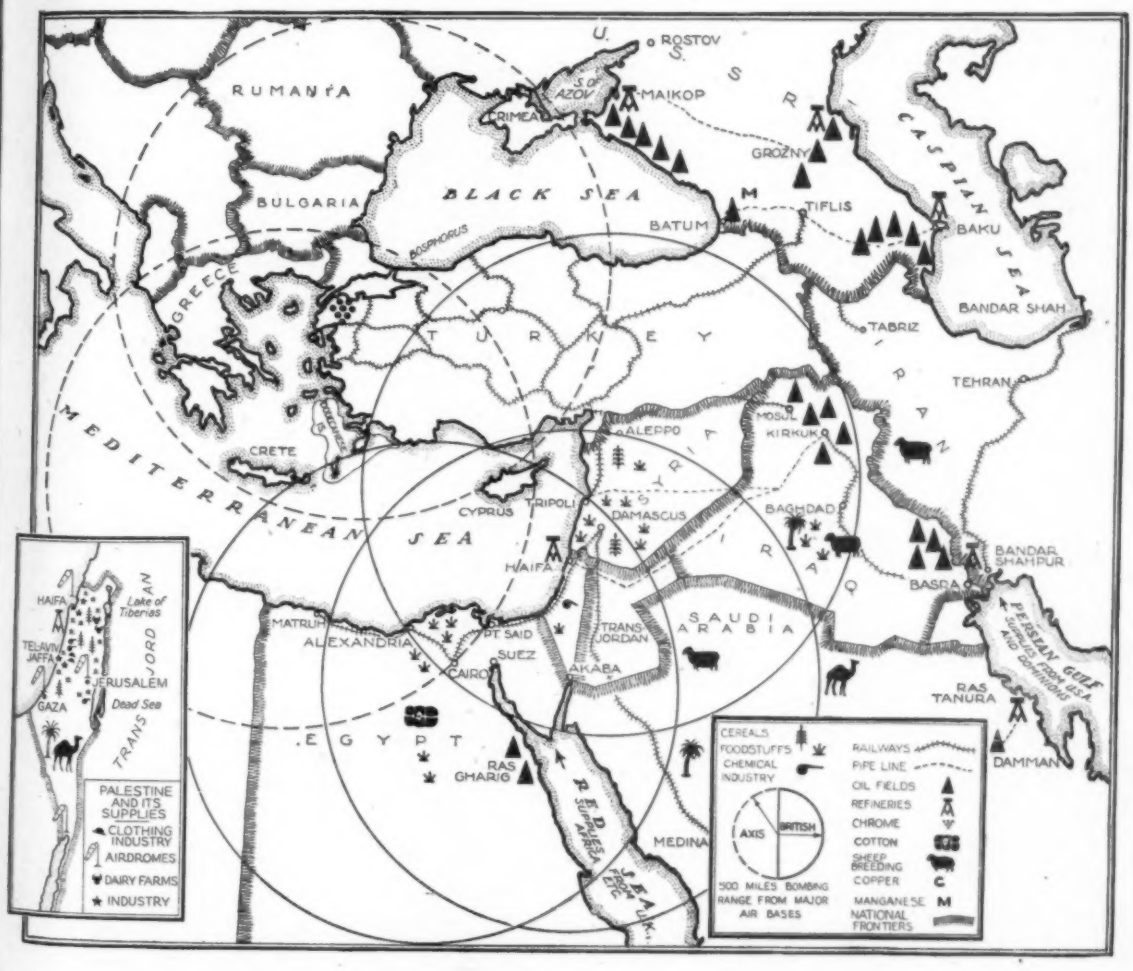
The Importance of Iran as Final Link in Chain from Indian Ocean to Taurus Mountains : Oil for Middle East Air Bases : The Allies' Advantages in Libya

ALLIED strength in the Middle East is gathering momentum every day. In the development of the war, this factor is of paramount significance. For there is no doubt that while at present the Nazis are preoccupied with their drive towards the Caucasus, at some opportune moment they intend to renew their push along the Mediterranean seaboard to Suez. That the initiative will remain with the Nazis is disproved by recent events. Britain's material strength is rapidly growing, especially in the Eastern Mediterranean, and it forms a formidable basis for the plan of military operations designed to eject the Axis from Libya.

With the occupation of Iran Britain's position in the Middle East has been substantially consolidated. From the Indian Ocean to the Taurus Mountains there stretches now a vast block of countries under Allied control or influence. This forms a formidable base for operations in this sector of the theatre of war. This tremendous area, covering over 1.2 million square miles and embracing a population of some 40 millions, is not only of potential strategic value ; it has resources in man power and supplies which, if efficiently husbanded for the war effort, could render invaluable services to the Allied cause.

Foremost among these supplies is oil. In Iran the crude oil is brought by pipes to Abadan on the Persian Gulf, the largest concentration of refinery production in the world. Here the full range of oil products is manufactured. Iraq's oil wells feed the refinery at Haifa, Palestine, by means of a pipe-line capable of handling some 2-4 million tons per annum, while Bahrein oilfields feed the refinery at Manama, capable of handling about 1.5 million tons in a year. Besides these vast resources, Egyptian oil production, though somewhat smaller in output, is steadily on the increase.

In addition to oil, the Middle East supplies also many other essential materials to the fighting forces, and this potential wealth could be still further exploited. The accompanying map shows the distribution of local supplies and the extent to which these areas are available for the operations of Allied forces. It will be seen that apart from



MIDDLE EAST SUPPLY LINES

locally available foodstuffs, which are of primary importance, there are local industrial centres comprising everything from engineering workshops to clothing, canvas equipment, metallurgical and chemical products. Foremost among them is the industry of Palestine, small if measured in European terms, but efficient, which is destined to play an increasingly important rôle in supplying the fighting forces in the Middle East. This industry already supplies a host of products such as army boots, clothing, optical instruments, chemical and medical supplies, and the technical skill of the immigrants represents an important asset in the widening of the Middle East supplies base.

Value of Local Supplies

These local supplies have yet another value: they represent a net saving in shipping space and tonnage and reduce the already heavy burden of the Allied shipping resources. Moreover, any product manufactured locally releases man power in Britain for the production of such essential supplies as are available elsewhere.

From further afield, from the Dominions and the U.S.A. vital supplies and equipment are coming in a steady flow to the Middle East bases via the Red Sea and the Persian Gulf. These supplies include substantial numbers of American aircraft, such as Curtiss Tomahawks and Martin Marylands, and the products of the armament industry of India, Australia and South Africa.

Thus Britain's air bases in the Middle East are not only supported by locally available fuel, labour and material resources; sea and air routes stretching outside the immediate combat area link them with important production centres of the Empire and the U.S.A.

The position of the Axis is entirely different. The favourable geographical distribution of the Axis bases in the Middle East is heavily outweighed by their inferior supply position. These bases have not the advantages of a hinterland of substantial supply potentialities nor of secure supply lines. To a great extent they are dependent on either the existing stocks or the maintenance of communications with the Italian and Greek mainland.

Libya is only a narrow strip of territory on the shores of the Mediterranean. A vast expanse of sand, this area does not produce anything but a meagre quantity of cereals and olives, barely sufficient to feed its local population. For the supply of the necessities for the Armed Forces, from foodstuffs to the all-important fuel, the Axis has to rely on shipborne, or to a lesser degree airborne, traffic across the Straits of Sicily and the Mediterranean. This dependence on outside supplies for even the most elementary commodities is a profound weakness of the Nazi air bases, and is common to Libya, Crete and the Dodecanese. For the Mediterranean is no more the "Mare Nostrum" to-day, than it was before. Roughly it can be compared to a pool with the British controlling the Western ingress, the Eastern seaboard and egress, and having Axis strongholds in the centre.

Seaborne traffic in these narrow waters is exposed to U-boat and aerial attacks and has been reduced by both parties. Gibraltar and Suez prevent Axis naval craft from slipping through and imperilling other oceans. How effective this control is, is best illustrated by the examples of Eritrea and Abyssinia, which were immediately cut off from their sources of supply in the Italian mainland and had to rely on their accumulated stocks. There is no doubt that the task of supplying Libya is somewhat easier than that of East Africa, and that considerable quantities of material have passed and are still being transported across the Straits of Sicily. But to the Axis the Mediterranean remains of first-class importance as a line of supplies; Nazi mastery of these sea routes would greatly enhance their position in Libya. Moreover, the disappearance of British stronghold exits would deprive the Middle East and Russia of supplies from the U.S.A. and the Empire.

While to the Allies, however, the West-East Mediterranean route is merely an improvement, since they can rely on their supply zone south of Suez, to the Axis forces in North Africa and elsewhere the security of the vertical North-South sea lanes is vitally important. "If for others the Mediterranean is a route"—said Signor Mussolini—"for us it is life itself."

Importance of Air Mastery

The mastery of the Mediterranean air space must therefore occupy an increasingly important share of the operations of Allied Forces in the Middle East. Unlike the Atlantic, where the vast expanse of the ocean and the lack of close bases limit the extent of aerial operations against convoys, in the Mediterranean both sides have at their disposal a fairly narrow-meshed net of air bases from which aircraft can operate and effectively hinder sea traffic. Air operations aimed at cutting and rendering insecure Nazi supply routes to Libya are growing in intensity and are of far-reaching importance.

Despite Greece, Sicily, Crete and the Dodecanese, Britain's air bases are well placed for such operations. First, because of the already mentioned supply lines, which make all the difference between isolated and advanced air bases, and those backed by immediate lines of communications to a hinterland with material resources. Secondly, because of the possibility of striking from Allied bases not only against vital enemy supply lines or stores, but against the very supply centres in Italy. Southern Italy's importance in the Axis supply system lies not so much in its industries as in the transport facilities and ports. From the Allied bases Italy's southern sector already feels the blow of the R.A.F. offensive. Relentless and persistent pressure of air operations against Libya and Southern Italy's railway junctions, dockyards, seaplane bases and industrial enterprises are an important part of the operations aimed at clearing the enemy out of Libya. It is essential that the Allies should maintain and increase not only local but absolute and constant aerial ascendancy in the Mediterranean air space.

VULTEE-CONSOLIDATED

IT is reported from America that negotiations are going on between Vultee Aircraft, Inc., and Major Reuben H. Fleet, president of Consolidated Aircraft Corporation, for the purchase by Vultee of Major Fleet's Consolidated interests. So far, according to a cable from Mr. Hugh Fenwick, Vultee vice-president, the negotiations are between Vultee and Major Fleet personally, but if they mature the combine would become one of the largest in the world.

The transaction is of particular interest to Great Britain because both concerns are delivering aircraft to us. The Vultee contribution to us includes the Vengeance dive bomber, while Consolidated are to build Boeing Flying Fortresses at Fort Worth, in addition to those now being built at San Diego, and are already building Liberator bombers and Catalina flying boats. Vultee Aircraft, Inc., produce a number of types for the American services, such as the Stinson Voyager, the Vigilant 0-49 observation type, and the Valiant basic trainer for the U.S. Army Air Corps. The Vanguard fighter is being built for China.

In the event of the transaction being carried through, the Vultee concern would wish to retain the extensive knowledge and long experience of Major Fleet in an advisory capacity.

REPAIRING WOODEN BLADES

How Scarfed Joints Can be Used to Make Damaged Wooden Airscrew Blades Serviceable : Strength of Glued Joints Independent of Blade Material

ONE of the advantages claimed for metal airscrew blades is the comparative ease with which they can be straightened and made serviceable after having sustained quite extensive damage in service. In our issue of November 20th we published an article by Mr. W. R. Chown, in which he presented the case for wooden airscrew blades. In that article Mr. Chown referred briefly to the question of repairs, and pointed out that Jablo blades can be repaired, in some cases at the service station and in many more cases at the factory.

We have now received from the Airscrew Co., Ltd., some notes on what one may term the Weybridge repair scheme. Here it might, perhaps, be explained that the fundamental feature of the Weybridge blades is that they are composed of woods of different densities, according to the position in the blades and the loads to be sustained there. At the root, for example, the wood is heavily compressed and of great strength, whereas in the working portion of the blade, where the loads are less severe, wood of lower density is employed. A repair depends upon a scarfed and glued joint, and it has been found that the strength of such a joint, that is to say, the glue strength per unit of glued area, is very nearly the same whether the two surfaces to be glued are spruce or oak. As the loads upon such a repaired joint are mainly due to centrifugal forces, it follows that a blade of low density will have the greatest strength factor after repair.

It is not generally known that there are on record many cases of Weybridge blades which have had three major repairs and are still being flown. The fact is testimony to the fundamental design explained above, and although it is not claimed that complete interchangeability has been achieved in every instance, the repairability can hardly be denied.

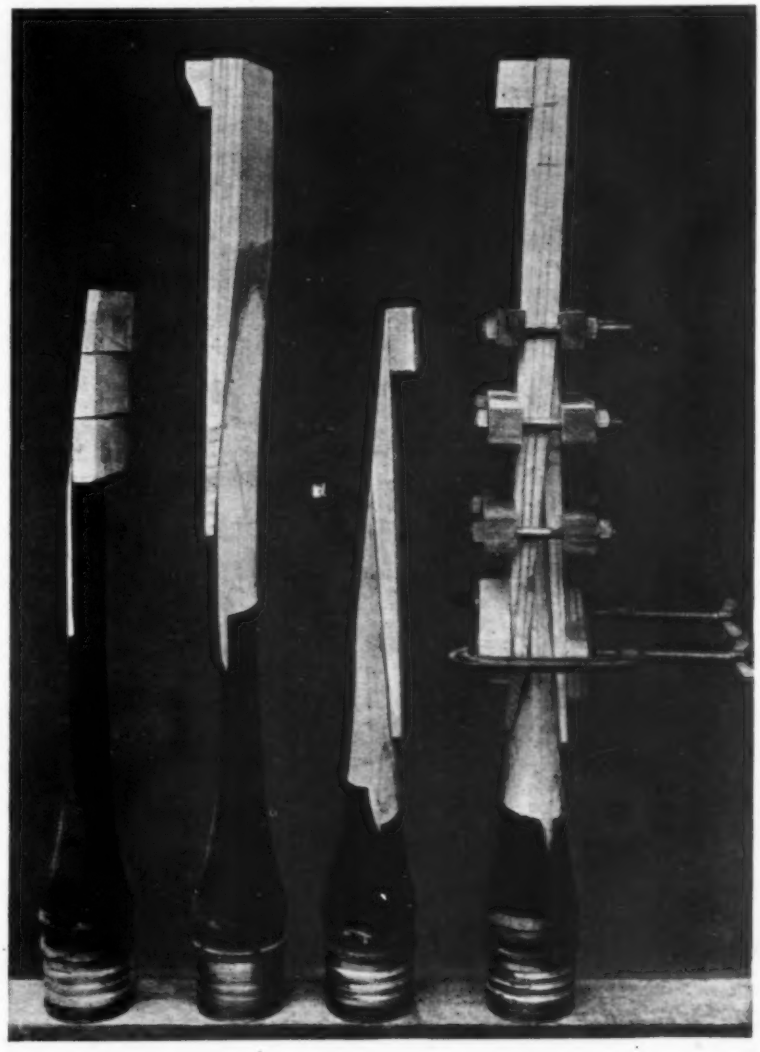
On the outbreak of war the Airscrew Co., Ltd., developed a repair service for their type of blades in order to conserve man-hours and materials. Various types of repair are executed, depending upon the portions of the blade damaged. In some cases, such as holes caused by cannon shells, a small portion of wood is grafted into the blade, but in others of major character a single-scarf glued joint of the good portion serves to hold a new portion of blade, which may constitute 50 per cent. of the total blade volume. Cases do occur, but of lesser frequency, when the blade is broken very close to the root; this necessitates a double-scarf joint being formed on the original portion. After the blade has been glued up with its repair block, it is shaped down to drawing and then is recovered with celluloid. In the case of blades with Schwarz covering, the brass sheathing is renewed if the repair is of major character.

The repaired blade is finally balanced against a master counterweight representing the static moment of the standard blade of the particular type. Cases have occurred where this has been found inconvenient. In such cases the blades of a type can be grouped into airscrew sets, each blade of a set being in balance with its fellows, but not interchangeable with other blades of that type.

Major and Minor

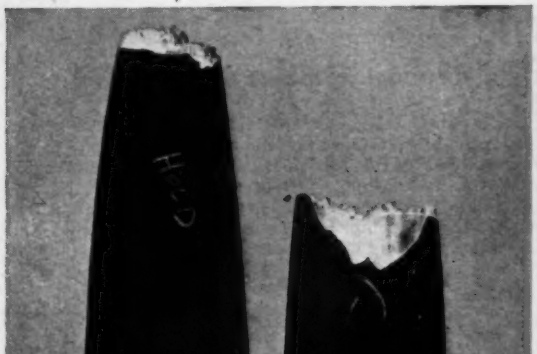
In our issue of October 30th, 1941, we published two photographs showing damaged and repaired airscrew blades. Some further information can now be added. The repair shown in the left-hand picture in that issue of *Flight* was, of course, of a minor nature. Such repairs are done to Airscrew Company specifications by Service repair depots and by the Rotol Company. When the breakage is a more serious one—that is to say, if there is damage or fracture near the root, for example—the repair is regarded as a major one, and the blade is returned to the Weybridge factory or to certain sub-contractors under the direct control of the Airscrew Company.

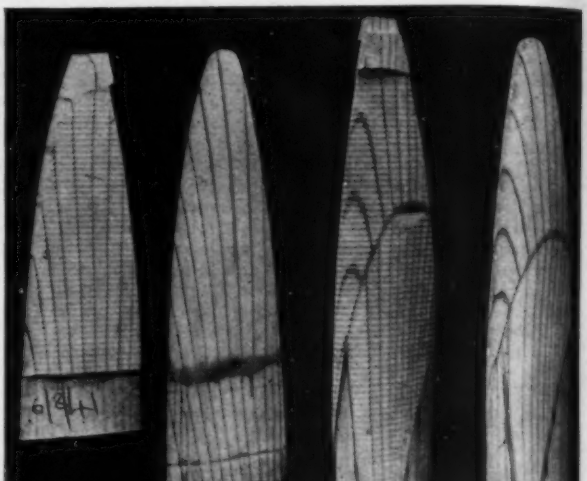
In conclusion, it is of interest to recall that it was the



Blades in various stages of single and double scarfed repair. The single scarf suffices when the damage is in the outer portion of the blade. If it occurs nearer to the root, a double scarf is necessary.

REPAIRING WOODEN BLADES





Before and after: On the left, the blades as received. Above, two stages in single and double scarf repairs.

Airscrew Company, and more specifically Dr. Henry C. Watts, who suggested to the Ministry of Aircraft Production that, although the scheme was opposed to a tradition of twenty years' standing, there was no reason why wooden airscrew blades should not be repaired. It was the Airscrew Company which evolved the technique of repairs, drew up all the specifications, and organised the general system.

It is sometimes held against repaired wooden blades that they cannot invariably be made 100 per cent. interchangeable. As has been stated above, there are instances when such a blade can be made to match up with any new blade of its own type. But even when it is necessary to match three particular blades in order to produce a serviceable airscrew, that is no great handicap. Many repaired metal blades have to be matched in the same way.

BOOK REVIEWS

The Observer's Book on Astro-Navigation, Part III. By Francis Chichester. George Allen and Unwin. 2s. 6d.

THIS is the third phase of what is ultimately intended to be a complete work on astro-navigation. In Part I the author dealt with the uses and limitations of air navigation by the heavenly bodies, and in Part II he went more into the mechanics of the subject. The present little treatise is largely a "Who's Who" among the stars and planets and includes a reproduction of the Flower Planisphere and Star Charts. Not the least valuable feature of Mr. Chichester's work is his undoubted flair for telling where accuracy is vital and where approximation is good enough.

First Stage Mathematics. By A. F. Buchan, B.Sc., and R. Borthwick, B.Sc. The University of London Press, Ltd. 2s.

OWING to its brevity, this little book caters well for the needs of those who wish to join the Royal Air Force, but who feel that they have long forgotten their school mathematics. Only essential processes are dealt with, each explanation being followed by numerous modern practical examples and exercises. Subjects range from simple arithmetic—vulgar fractions, decimals, etc.—up to the triangle of forces and trigonometry. Logarithms and trigonometrical tables are included, as are the answers to all exercises. This book should be especially useful to air crew candidates wishing to attain I.T.W. standard before entry.

"The Observer's Book on Meteorology." By W. J. D. Allan and William Alexander. George Allen and Unwin. 2s. 6d.

THE authors of this book are both ground instructors at one of our largest R.A.F. training schools, and in the first chapter they point out that a knowledge of the causes of varying weather conditions enables the airman to take advantage of favourable factors and avoid the dangerous ones. Their book, therefore, endeavours to explain in simple language the causes and reasons for weather changes—winds, storms, rain, snow, hail, fog and ice accretion—and no doubt many readers will learn, for the first time, the significance of that "depression" so popular with the B.B.C. in their peacetime weather forecasts.

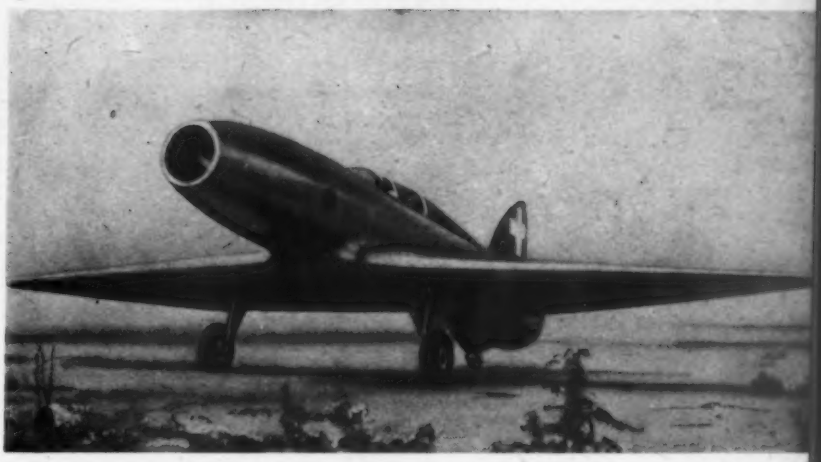
"Behind the Spitfires." By RAFF. Methuen. 5s.

THIS is life on a fighter station as seen through the eyes of an "erk" with a nice sense of humour and a distinct gift for sketching. Furthermore, it introduces "Aircraftman Plonk" (the R.A.F. counterpart of Tommy Atkins and Jack Tar) from the moment he hears on the radio that war has been declared. Through 104 pages of delightfully comic sketches we follow him during his enlistment, training, posting to his squadron, his final arrival at the estate of fully-fledged airman, his leave and his reactions to the changes that have befallen during his absence from his home town. There is also an amusing but indispensable glossary of terms appended.

JET PROPULSION of AIRCRAFT

More Details of Italian Experiments and a Photograph of the Campini Design

By G. GEOFFREY SMITH, M.B.E.



SANS AIRSCREW: First photograph of a jet-propelled aircraft — the Campini—which is discussed in the accompanying notes.

IN discussing the subject of Jet Propulsion in a series of four articles in *Flight* for August 28th, September 11th and 25th, and October 9th, reference was made to an Italian design. The original article included a sectional drawing of this jet-propelled machine for stratosphere flight at either sub- or supersonic speeds as proposed by Engineer S. Campini, of the Caproni Aircraft Group in 1932. It now transpires that this particular scheme, which was obtained from a French patent specification, was not the one proceeded with. A photograph has now come into our possession which indicates big changes from the earlier lay-out, and we repeat the drawing of the latter for comparison. Incidentally, the accompanying half-tone illustration of the later type is unquestionably the very first to be reproduced in this country of a jet-propelled type of aircraft, no other journal having either discussed the internal mechanism, or shown by examples this new and intriguing form of prime mover. Cynics who found difficulty in believing that an aircraft could be propelled through the air without the aid of either an orthodox power unit or airscrew (see the Correspondence pages of *Flight*) may be more ready to accept the promise of "things to come" by this photographic evidence.

Flown Last Year

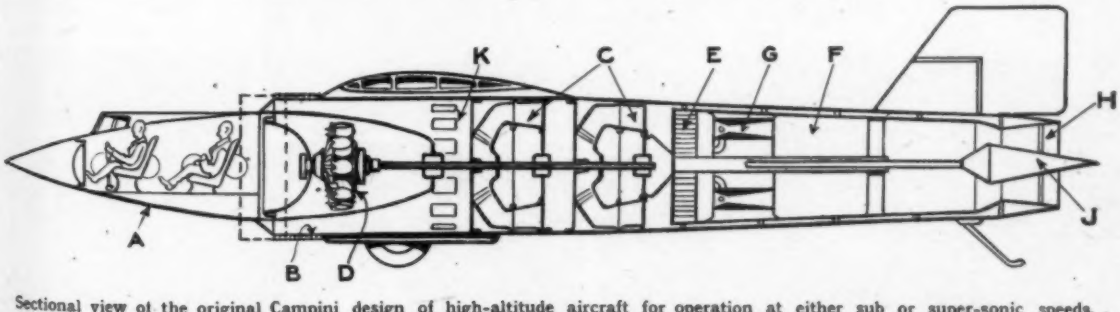
The type illustrated is evidently the latest conception of Campini, and is the one first flown successfully for ten minutes from the Forlanini Aerodrome, Milan, in August of 1940. It differs radically from the original layout, for the pilot is apparently accommodated in a cockpit between the wings, and not in the nose of the fuselage as in the original plan. A low-wing monoplane with two seats in tandem, is now preferred, with curious heavy-looking wing roots and undercarriage with legs retracting outwardly whereas the nine-year-old layout was for a high-wing monoplane of entirely different form. Furthermore, the air stream is now taken in through a circular opening in the front of the fuselage instead of via the annular space between the pressure-charged cabin and the enshrouding fuselage as in the first design. According to the bare particulars revealed of the new type, at low altitudes the air is subjected to an initial compression by the forward motion of the aircraft. The air is additionally compressed by means of a blower driven by the engine, which may be a nine-cylinder radial type, as on the early design, or possibly a turbine is referred to.

To utilise to the fullest extent the latent heat of the fuel, the exhaust of the engine discharges directly into the main airstream, adding heat and still further increasing the pressure of the air. For high-altitude flight at high speeds a further supply of fuel, introduced through supplementary burners, may be utilised to furnish additional heat. In this manner the mass and velocity of the jet, and consequently the thrust, are increased.

Control of Airstream

The airstream is controlled by the pilot by means of a cone on the end of a shaft which is arranged to slide longitudinally. This cone has the effect of varying the cross-sectional area of the jet orifice, and thereby the speed of the propulsive jet. The tail end of the fuselage is exceptionally large in diameter, as the photograph shows, in order to accommodate this feature, which presumably follows the previous scheme illustrated in the sectional drawing.

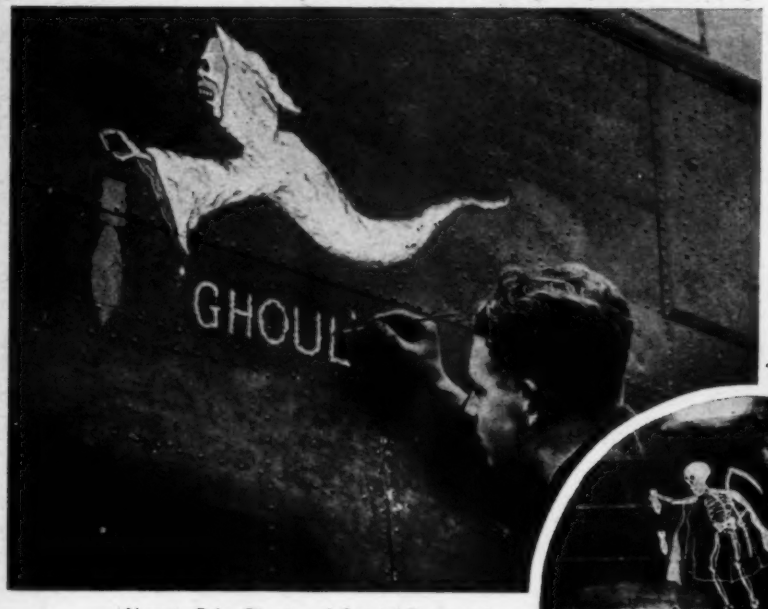
This new Italian design was referred to by A. Guglielmetti in a lecture to the Lilienthal Society of Berlin last summer on the line of Development of Italian Aircraft Design. After pointing out the limitations of propeller efficiency at high altitudes and the need for (*a*) more than one airscrew for single engines, or (*b*) subdividing the power plant, he considered that, on the other hand, at low altitudes the provision of several engines driving one propeller is worthy of consideration. It was the increasing difficulty of obtaining reasonable propulsive efficiency at high speeds and high altitudes with the orthodox power plant that had, in his judgment, led to the increased attention being paid to jet propulsion.



Sectional view of the original Campini design of high-altitude aircraft for operation at either sub or super-sonic speeds. A, Ovoid cabin; B, Enshrouding cylinder; C, Two-stage centrifugal compressor; D, Radial engine; E, Rectifier radiator; F, Combustion space; G, Annular mixing channel; H, Discharge nozzle; J, Cone for varying nozzle orifice; K, Controlled lateral orifices.

AMATEUR EMBLEMS

A Selection of Cartoons Adorning the Fuselages of R.A.F. Aircraft



(Above) G for Ghoul. A Coastal Command Beaufort.

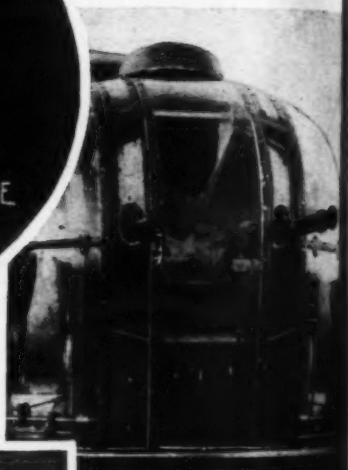
(Below) C for Churchill. Another Beaufort of Coastal Command.

P for Popeye. A Hampden of Bomber Command.

(Above) This should leave some of the enemy cold.

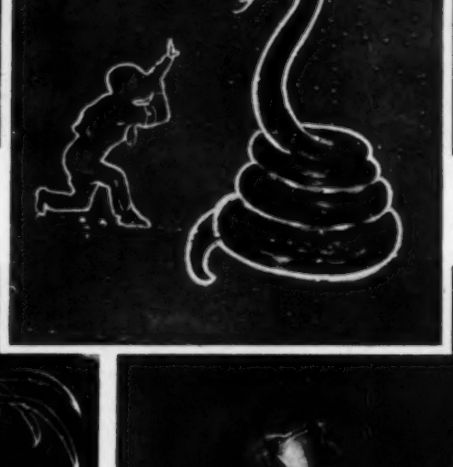
(Right) A for Adder. A charming study

(Below) The Gamecock sported by Sqn. Ldr. Dalton Morgan, D.F.C. and Bar, on his Hurricane.



(Above) A cheering target for German night-fighters.

(Below) This Hurricane pilot's nationality could almost be guessed.



ATLANTIC FERRY

The officer in charge of the control tower at the R.A.F. Atlantic Ferry Command in Canada watches yet another American bomber arrive at the seaboard ferry base from its factory.

U.S. Air Corps and R.A.F. Ferry Commands Co-operate in Delivering Bombers from American Factories to Britain

CLOSE co-operation between the U.S. Army Air Corps Ferry Command and the R.A.F. Atlantic Ferry Command is the keynote of a huge organisation which has now been built up for the sole purpose of getting American-built aircraft from their factories to Great Britain with the least possible delay, and it is a tribute to the combined efficiency of both sections of this intricate organisation that, since the Atlantic Ferry service was begun a year ago hundreds have been delivered under their own power.

The American end of the organisation is a comparatively recent institution. Up to a few months ago, machines to be flown or shipped to Great Britain were flown from the factories to the ferry bases, or crating centres, by civilian pilots. Then the U.S. Army Air Corps took over the task and Col. Robert Olds was instructed to organise the new Ferry Command. In four months he built up what at least one American journalist has described as "an air transit organisation which may dwarf the flying activity of all U.S. airlines put together before the emergency is over."

Express Delivery

One great advantage to the Americans of the new arrangement is that it gives useful flying experience to Army pilots, particularly on multi-engined types. But the advantage to Great Britain is even more obvious, for the time taken to deliver a bomber from factory to seaboard ferry base has been about halved compared with the time taken for these flights when the Command was inaugurated. Three days is the average delivery time, and the Command is organised to cope with President Roosevelt's programme for 50,000 aircraft a year. Operating at ten different stations throughout the country, the Command to-day has some 300 ferry pilots and nearly 2,000 mechanics, apart from administrative ground staff.

Montreal, Canada, and Miami, Florida, are the two delivery points at present (the latter is the Pan American Airways ferry base), and in Canada the American Army Air Corps pilots hand over the machines to the British Atlantic Ferry Command for the flight to Great Britain.

"Atfero" was formerly the body responsible for the Atlantic flight and was under the administration of the Ministry of Aircraft Production Now, however, the Air Ministry has taken over responsibility and the renamed Atlantic Ferry Command includes a proportion of R.A.F. personnel and is, in fact, an R.A.F. Command in Canada. But its pilots are all civilians and a large proportion are

Atlantic Ferry pilots study the weather map before starting their ocean hop. The officer in the foreground is wearing A.T.A. uniform.

MIND THOSE FLASKS! The American pilot in A.T.A. uniform seems to be concerned about the coffee flasks as his navigator collects their gear in preparation for the trans-atlantic flight in the new Hudson. The interested looker-on in the doorway is the radio officer. A few hours after this picture was snapped they handed the aircraft over on an R.A.F. station in Britain.

American citizens, including some who originally joined the Air Transport Auxiliary in this country and have now transferred to the Atlantic Ferry Command.

Most of the navigators, however, are R.A.F. men, while the ground staff also includes some R.A.F. personnel. Incidentally, all radio operators must be British subjects.

When the flying of American bombers across the Atlantic to R.A.F. stations in this country first began, the ferry pilots were mostly taken back to Canada by sea, which wasted a lot of time and exposed them to the risks of encountering enemy submarines and surface raiders. Nowadays, however, they are flown back (Liberators are largely used for this important duty) in far greater safety and far less time. Another vital factor in the speed-up of deliveries is the method adopted by the U.S. Ferry Command for dealing with temporary hold-ups in the delivery of items of equipment at the factory.

To cope with this incidental but important aspect of the job, a number of "installation points" have been established where aircraft on their way to Canada or Florida can call to have some necessary fitment added. Such equipment is, needless to say, of a character which does not prevent the machine setting off from its birthplace without it. Wayne County, Detroit, Michigan, is the principal installation point, and Nashville, Tennessee, is being developed in the south, chiefly for aircraft on their way to Florida and the Middle East.

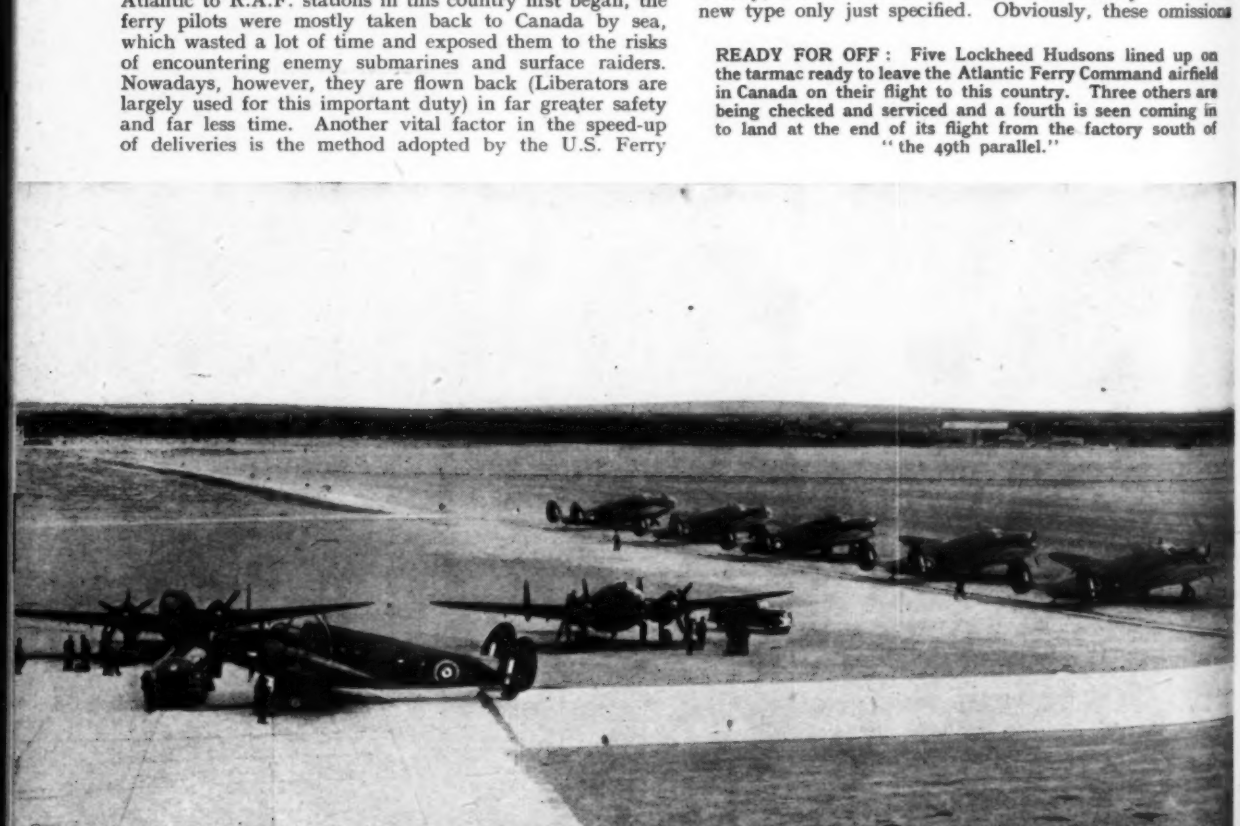
Specification Changes

It should be stressed here that shortages in equipment on a machine leaving the assembly line in some American factory are not necessarily due to ordinary delays in delivery on the part of an accessory manufacturer; they are often caused by changes in specification which are constantly being made to conform with war needs. Production shortages, brought about by a variety of causes, are responsible for the balance, but the important point is that if every aircraft were kept at the factory until every item of equipment were complete, much valuable time would be lost, so it is allowed to begin its journey to the seaboard (so long as its equipment is sufficiently complete to fly in safety) and to collect its missing items of equipment at an installation point on the way.

For this plan to work smoothly it is obvious that fittings which did not reach the aircraft factory in time to be added before the aircraft left must be deflected to the appropriate installation point instead of being despatched to the factory in the ordinary course of routine deliveries. The head office of the U.S. Army Air Corps Ferry Command looks after this from the first floor of the Munitions Building in Washington, and this is what happens.

Let us suppose that a bomber is ready to leave the factory, but is short of flare racks and safety belts of a new type only just specified. Obviously, these omissions

READY FOR OFF: Five Lockheed Hudsons lined up on the tarmac ready to leave the Atlantic Ferry Command airfield in Canada on their flight to this country. Three others are being checked and serviced and a fourth is seen coming in to land at the end of its flight from the factory south of "the 49th parallel."



do not prevent the machine from being flown. The Washington office is informed by teleprinter of these shortages and orders the aircraft to call at the most convenient installation point, say Wayne County, who are duly informed that when bomber No. —— arrives, there will be flare racks to install. At the same time, the necessary steps are taken to see that these are deflected to the Wayne County installation point instead of being despatched direct to the factory.

But the matter of the seat belts raises an additional point, for the Ferry Command will not accept the machine from the factory for delivery to the seaboard without safety belts for its pilots. So the Air Corps liaison officer attached to the Ferry Command office at Washington has also been getting busy, and has found that the depot at, say, Sacramento, has 50 spare seat belts of the regulation Army type. These will not be accepted by the British authorities instead of the new type specified, but at least they will do as a safety provision for the American Army Air Corps pilots who have to deliver the aircraft to Montreal. So it is arranged that the next Army cargo plane through Sacramento shall pick up these 50 belts and take them on to the factory where the bomber is waiting to start its eastward journey overland. While its pilots are waiting, they carry out a final check of the aircraft and study their flight plan and weather charts.

Alternative Provision

Whether the new British-type belts will be sent to Wayne County or to Montreal depends on how soon they can be delivered. If they can be got to the installation point in time to be fitted at the same time as the flare racks, all well and good. If not, then the R.A.F. Atlantic Ferry Command at Montreal is advised that the new belts for such and such a bomber, now on its way with temporary American-style belts, will be delivered direct to them. Assuming this course is agreed, then the suppliers of the new-type belts are advised accordingly.

The bomber then sets off from the factory with the temporary safety belts, calls at Wayne County installation point to have its flare racks fitted, and, in most cases, would find its required safety belts waiting for it at Montreal on arrival there. But even if the new belts did not reach Montreal until later, the bomber is already in the hands of the R.A.F Atlantic Ferry Command, and, with the usual inspection and final check-up and servicing completed in the meantime, is all ready to hop off for England the moment this last item of its equipment is added. The enormous saving in delivery time, compared with having to wait at its factory, perhaps on the other side of America, until these two items of its equipment had been duly delivered and fitted, will be obvious to everybody.

The above, of course, is only a brief outline of the method by which delays in the supply of what may be termed "minor equipment" is not allowed unduly to delay the handing over of the machines to the British ferry people at the seaboard. In actual practice it involves a decidedly intricate network of communications and transportation to make sure that the required equipment reaches the right place at the right time. Full use is made of U.S. Army aircraft in collecting such material wherever it may happen to be located and carrying it swiftly to the desired installation point This does not necessarily mean that U.S. Army pilots are being regularly used as special delivery messengers for their Ferry Command. Military aircraft are constantly flying about the country, between the important centres, on their normal duties, and it is generally possible to arrange for one of these to make a call along its intended route, or perhaps to make a slight detour, in order to kill two birds with one stone.

It is due to the fact that the Army Air Corps has taken over the factory-to-seaboard ferrying, however, that urgently needed equipment can be quickly located. Sometimes, indeed, it is supplied direct from the Army's own stocks at various bases, but it may equally easily be drawn from lease-lend supplies or diverted from Army contracts. From reports on the working of the scheme which have reached us here, it seems clear that the organisation has been given a commendable elasticity in this respect.

EASTWARD HO! The crew of a Hudson look out over some 2,000 miles of ocean at the start of their transatlantic flight. The civilian pilot sports a snappy line in American headwear, while the R.A.F. corporal checks their course and the radio officer exchanges a few final remarks with the ground station.

OVER TO YOU! A corporal in the wireless room at the R.A.F. Atlantic Ferry Command in Canada carries out a final check-up with the Hudson which has just set out on its ocean "hop" to Great Britain—the second stage in the delivery service of American aircraft to the R.A.F., run in co-operation with the U.S. Army Air Corps Ferry Command.

Fifteenth of the Second Series

FRIEND or FOE ?

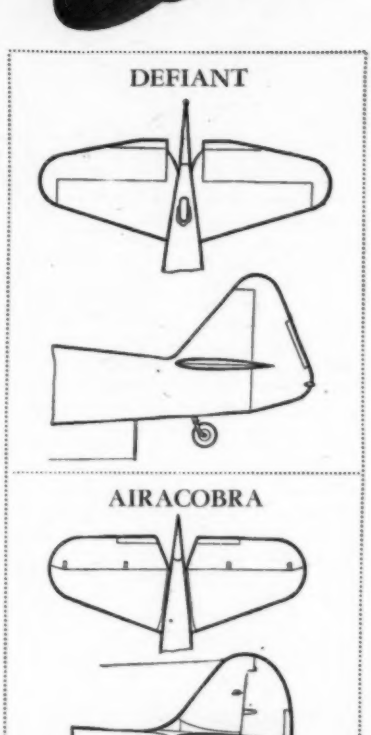
Outstanding British and American Fighters : Defiant and Airacobra

DEFIANT : Triangular fin and rudder. Tapered tail-plane with straight-edged "bite" in trailing-edge. Retractable wireless mast near fixed tail wheel.

BOTH the Boulton-Paul Defiant and the Bell Airacobra are outstanding aircraft, each in its own way, and have characteristics not shared by any other fighter. The former is the only single-engined two-seater fighter in the R.A.F. equipped with a power-operated gun turret (just as the Blackburn Roc is the sole representative of this type in the Fleet Air Arm), and the Airacobra is the only fighter in service with any air force with a single engine placed amidships in the fuselage.

But while the Defiant is instantly recognisable by virtue of its unusual armament, the Airacobra's general appearance does not depart materially from that of the normal run of single-engined fighters having in-line, liquid-cooled power units. It so happens, also, that the tail-unit of the Defiant is particularly helpful in the matter of identification, whereas that of the Airacobra is not remarkable for any radical divergence from the usual. This, incidentally, is no criticism of the American machine, which is in every way a particularly good-looking aircraft—in the opinion of many, including the writer, the Airacobra is, in fact, one of the most gracefully proportioned single-engined aircraft in existence to-day.

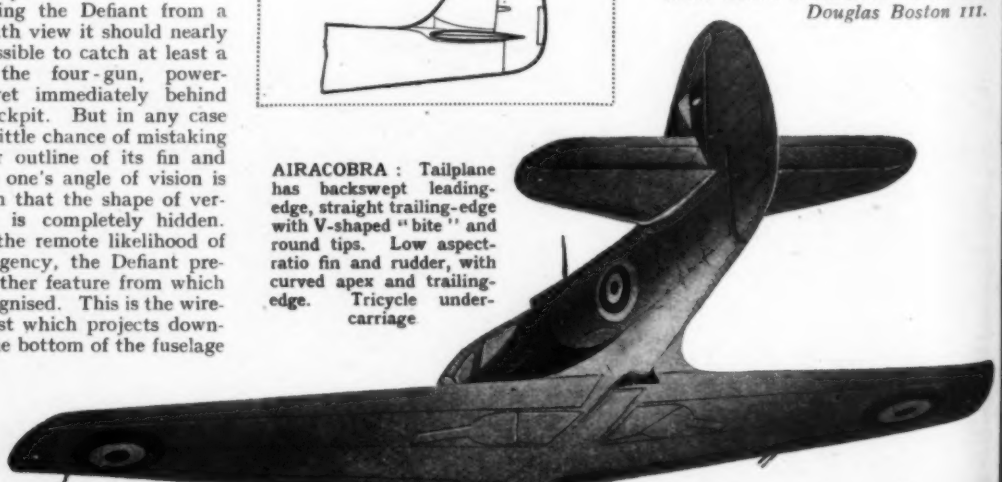
In identifying the Defiant from a rear underneath view it should nearly always be possible to catch at least a glimpse of the four-gun, power-operated turret immediately behind the pilot's cockpit. But in any case there can be little chance of mistaking the triangular outline of its fin and rudder unless one's angle of vision is so dead astern that the shape of vertical surfaces is completely hidden. However, in the remote likelihood of such a contingency, the Defiant presents still another feature from which it may be recognised. This is the wireless aerial mast which projects downwards from the bottom of the fuselage just in front of the non-retracting tail wheel. A similar mast projects below the centre-section of the wings, but we are primarily concerned here with the aft end of the aircraft. These masts retract, of course, but will be visible under reasonable good conditions when the machine is in flight.



The Defiant's tailplane, which is well tapered on both edges to small round tips, also has an unusual feature in that the "bite" which allows rudder clearance between the elevators has parallel edges; reference to the accompanying drawings will show exactly how they are formed.

The tailplane of the Airacobra has a pronounced backsweep to its leading-edge, a straight trailing-edge with V-shaped "bite" and small round tips. Its fin and rudder are of comparatively low aspect-ratio, and have a straight leading-edge with a small concave radius at the foot, a well-rounded apex and a curved trailing-edge that blends into the underside of the fuselage. It has a tricycle undercarriage. Other points which may be visible from the rear (see the illustration below) are the exhaust outlets from the amidships engine and the air-intake behind the fairing of the pilot's cockpit.

Next week: Blackburn Botha and Douglas Boston III.



AIRACOBRA : Tailplane has backswept leading-edge, straight trailing-edge with V-shaped "bite" and round tips. Low aspect-ratio fin and rudder, with curved apex and trailing-edge. Tricycle undercarriage

Correspondence

The Editor does not hold himself responsible for the views expressed by correspondents. The names and addresses of the writers, not necessarily for publication, must in all cases accompany letters.

CAMERA CURIOSITY

Apparent Airscrew Position

I HAVE seen many photographs of single-engined aircraft in flight in numbers, and in these photographs all of the airscrews are in the same position. Perhaps this does not occur for every type of single-engined machine, but I have seen it in photographs of Defiants and Hurricanes.

Could you please give me some explanation of this occurrence as it has puzzled me a great deal? Have any other readers of *Flight* noticed this strange happening?

Please keep up the good work. *Flight* is an excellent aeronautical magazine. A PUZZLED SCHOOLBOY.

TARGETS FOR TO-MORROW

A Job for the Beauforts?

I HAVE often wondered why the R.A.F. pilots do not take more interest in the big French hydraulic power stations. It seems that a well-directed submarine torpedo exploding on the bottom of the artificial lake feeding the turbines at the lower part of the dam would be very effective—the water pressure would then complete the job.

An artificial lake is easily detected from the air, and a dam is a ready target for a torpedo.

Power stations such as the Forces du Rhône, La Truyère and Les Forces de la Vienne being put out of action would mean closing a large number of French factories serving the Boche war machine, and a large calibre torpedo in the dam of the Lake des Bouillouses would put a stop to 95 per cent. of the German railway traffic in Southern France.

The "Collaborationistes" would certainly object to this very unfair treatment, but who cares? S. HOLMAY.

NAMES TO INSPIRE

Apply Them to Squadrons

IN your issue of November 6th your correspondent, "Draughtsman," suggests that the names of our great designers, such as R. J. Mitchell and S. Camm, be used in the nomenclature of our latest types of aircraft. Personally, I like the idea very much, for no honour can be too high for the men who gave us the Spitfire and the Hurricane.

I should like to suggest, however, that such names should be used, not for types, which grow obsolete and disappear from memory in a few years, but for squadrons.

The custom of naming squadrons started before the war only in the Auxiliary Air Force, but has lately spread, and we now have squadrons named after generous donors of funds, such as the Hyderabad Squadron. I should like to see every squadron in the Service given a name, for numbers are cold and rather uninspiring things, and to have a Mitchell Squadron, a Camm Squadron and a Roe Squadron, etc., would be a worthy memorial of really great servants of their country.

TENDERFOOT.

FIGHTER DESIGN

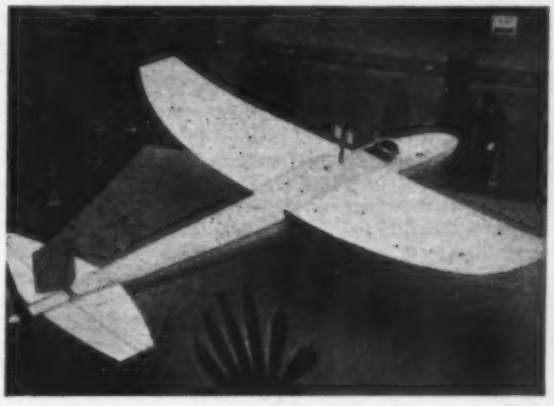
Nothing New Under the Sun

YOUR first leading article in *Flight* of November 27th begins with the old saying, "There is nothing new under the sun," and you quote several cases of "new" inventions having been discovered actually to be quite ancient. You also warn readers not to condemn a thing because it has been tried and has failed.

By a curious coincidence, your Correspondence page in the same issue affords an example of both. The fighter design suggested by Mr. P. Taylor (who, I seem to remember from previous correspondence, is a youngster of 17 or so) seems to me to have very considerable merit. The tricycle undercarriage affords a certain degree of protection for the tips of the airscrew blades, although it does not seem quite to guard them against all possibility of damage. I am thinking of the case when the pilot makes the last bit of his approach in the tail-down attitude of the orthodox three-point landing, as he must do to lose speed, even if he brings the tail up before touching down. If that manœuvre is left a little late, the tips might conceivably touch the ground. However, doubtless that point could be got over. By the way, the Taylor design seems to lend itself admirably to contra-rotating airscrews.

And now I come to my second point. The idea is not new, I am sure. I cannot trace the references, as I have had to abandon my old volumes of *Flight*, but I am fairly certain that in about 1912 or so there was a French monoplane which had its propeller (that was what we, sensibly, called them in those days) in the extreme stern. Perhaps the Editor can corroborate my statement. If I am correct, the airscrew-in-the-extreme-stern idea is not new, and from the fact that it was not adopted one may put the arrangement down as a failure. But as the Editor said last week, one should be chary of condemning a thing because it was not initially a success. Mr. Taylor is obviously too young to have had any knowledge of that early attempt (if I am right in thinking it was made) and so it must be a case of "great minds thinking alike."

"NINETEEN-TENNER."



The Paulhan-Tatin "Aerial Torpedo" of 1911. The engine was a 50 h.p. Gnome rotary, driving an airscrew located in the extreme stern.

[Our correspondent is perfectly correct. The machine to which he refers was the Paulhan-Tatin "Aerial Torpedo," and it was exhibited at the Paris Aero Show in 1911. The engine was a 50 h.p. Gnome rotary, housed inside the fuselage behind the pilot. The driving shaft was a long steel tube. It was claimed that the machine had attained a speed of 140 km. per hour. Another interesting feature of the design was that there was neither wing warping nor ailerons, so that the *Torpille Aerienne* was an early example of a two-control aircraft. It seems likely that it was this fact rather than the location of the airscrew which prevented it from being a success.—ED.]

GUN CALIBRES

A Plea for Uniform Figures

MAY I voice a plea for some kind of uniformity in describing the calibres of the various sized machine guns fitted to military aircraft?

It is obviously convenient to add a couple of noughts when referring to the American 0.3in. gun in order to avoid possible confusion with the British 0.303in. calibre, but for some inexplicable reason (perhaps for no reason at all) the "half-inch" weapon is variously written down as 0.5in., 0.50in. and 0.500in.

I suggest that as long as the 0.303in. is in use the other two should always be termed 0.300in. and 0.500in. respectively.

"TRIGGER."

BEATING OFF ATTACK

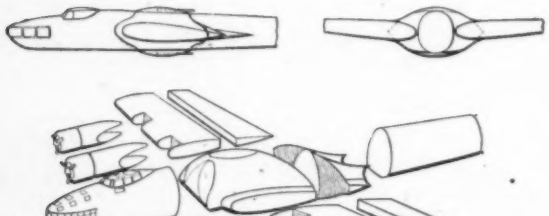
Novel Arrangements of Defensive Armament : Designing Aircraft Around the Gun Turrets : Alternatives to "Tail-end Charlie"

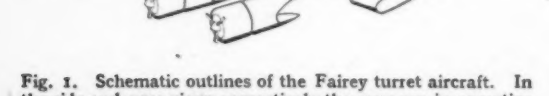
FOR a great many years the experts have been, and still are for that matter, divided on the question of whether a bomber should be large, so as to be able to carry a very heavy bomb load, and provided with elaborate defensive armament to enable it to beat off enemy fighters, or whether it should be small and very fast, depending on its speed for its immunity from attack.

Germany followed the latter policy, whereas Great Britain chose the larger and somewhat slow bomber, giving it a powerful defensive armament in the form of power-driven gun turrets. Quite early in the war it became evident that the German bombers were not fast enough to evade attack by our fighters. That did not prove that the idea of the fast and almost unarmed bomber was wrong. It merely proved that the Germans had not made their bombers fast enough. The British bombers of the early war period, although much slower than some of the German bombers, did not suffer to the same extent, thanks to their gun turrets.

There is, however, no denying the fact that all these "hen coops," "greenhouses," "dustbins," "blisters" and "armpits" caused excessive drag, and in some instances gave a rather restricted field of fire. Moreover, in some cases the space was so cramped that the rear gunner had to be isolated from the rest of the crew throughout the flight, and it was almost impossible to give him that armour protection which could be afforded other members of the crew.

That designers were not unaware of these drawbacks was shown by the attempts to introduce remotely controlled guns (see *Flight* of February 29, 1940), partly with a view to centralise and protect the gunners' positions and partly to economise in the number of crew carried. The schemes have not come into general use, and the gun turret still holds the field.





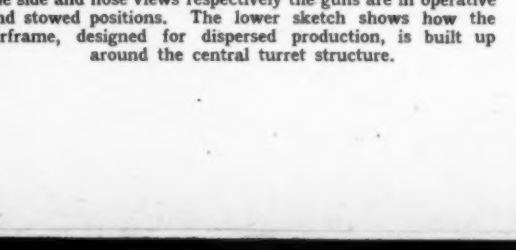


Fig. 1. Schematic outlines of the Fairey turret aircraft. In the side and nose views respectively the guns are in operative and stowed positions. The lower sketch shows how the airframe, designed for dispersed production, is built up around the central turret structure.

A New Conception

Now the Fairey Aviation Co., Ltd., have carried this reasoning to its logical conclusion. An aircraft and its main defensive armament have been designed as a complementary whole. This has necessitated a special type of fuselage construction and also a new duplex, multi-gun, retractable turret. The construction is indicated schematically in the perspective sketch. At the intersection of the wings and fuselage is a centre section which is basically a lenticular structure, adapted to accommodate upper and lower rotatable turrets, each mounting four guns. This centre section is provided with appropriate faces and wing roots for the attachment of other component units, and the whole design is laid out for the dispersed production of such units in accordance with current practice.

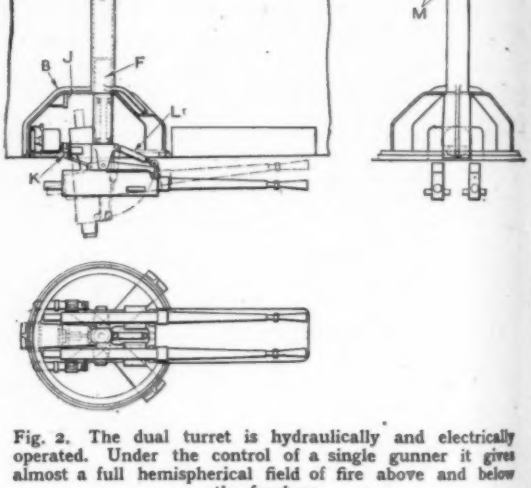


Fig. 2. The dual turret is hydraulically and electrically operated. Under the control of a single gunner it gives almost a full hemispherical field of fire above and below the fuselage.

Both the upper and the lower turrets may be projected from the fuselage to bring them into the operative position. When stowed, as shown in the illustrations, the turrets present a better streamline form than that provided by turrets of more usual construction. This centralised location enables the aircraft to be protected most effectively against attack from above or below and from almost any angle. With upper and lower groups of guns, each capable of rotation through 360 deg. and

elevation through an arc of 90 deg., there is virtually an unrestricted field of fire.

The Power-operated Dual Turret

The second illustration shows a two-gun turret with the upper guns stowed and the lower ones dropped to the operative position. The elevating range is indicated in dotted outlines. Gun cradles are raised and lowered, locked in either position, and elevated by hydraulic means and traversed in azimuth by an electric motor. When retracted the guns are stowed in recesses in the fuselage and covered by suitable flaps to maintain a clean exterior surface. Forming the main supporting structure, the hydraulic cylinder A terminating at each end in a spider frame B, is securely fixed to the fuselage. On each spider is mounted an annular turntable C, carrying an electric motor D, which, through a reducing gear, drives a pinion meshing with a circular rack E on the spider. Each hydraulic ram F has a cradle seating G, on which is a hydraulically operated, spring-loaded locking bolt H, which engages apertured lug J on the spider or lug K on the turntable when the guns are in their stowed or exposed position respectively. Trunnioned to the seating G, the gun cradle is elevated or depressed by means of a pivotally-mounted hydraulic strut L.

Control of each group of guns is normally effected independently by one of a pair of handles M mounted side-by-side at a convenient height on the main hydraulic cylinder A. If desired, however, a single handle may be arranged to control both groups simultaneously. Gun firing triggers are, of course, mounted on the handles.

Additional to the improved field of fire there are manifest advantages in such an arrangement from the point of view of operation. Only one gunner is required to deal with attack from all quarters. Housed in the centre of the fuselage he can, if necessary, duplicate his duties, and it thus becomes possible for him to serve as a radio operator, navigator or bomb aimer. Conveniently both he and the guns can be better protected from enemy action than in the usual exposed position. Should a gunner be incapacitated, however, other members of the crew have access to the gun post, and can continue the defence against attack. Patents have been granted for the aircraft, gun turret, control gear and sighting gear.

A German Fighter Design

Although the two-seater fighter is specifically an offensive machine, it also has need for defensive armament unless it possesses a marked superiority in speed and manœuvrability over opposing aircraft. British policy in this respect is well known, and for a considerable time we have had highly developed two-seater fighters in commission. In these the pilot controls fixed forward guns, and for the gunner a power-operated turret is provided.

The Germans would appear to have some unusual ideas on the subject. It is stated that fighters, presumably only experimental types, have been constructed with fixed guns directed both to the front and the rear. With the control of the machine in the hands of the usual pilot, the rear guns would be virtually useless. Accordingly, dual controls were fitted, and a second pilot was seated facing to the rear. In the event of pursuit the forward control could temporarily be locked and the machine manœuvred by the rear pilot in order to keep the opponent in his field of fire.

Such a machine would seem to demand perfectly co-ordinated team work by the two pilots. "Changing horses in mid-stream" would be child's play to swopping controls at 400 m.p.h. with a Spitfire diving on your tail. The following German account of the difficulties, however, cannot be bettered. "It is obvious that the control of the aircraft by the rearwardly looking pilot did not at all times coincide with the wishes of the forwardly looking pilot, particularly if the control action of the pilot could be temporarily blocked. Situations might, therefore, arise in which the steering of the aircraft by the aft gunner or pilot would interfere with the proper control of the aircraft, and might lead to disaster."

Fig. 3. "That's a Dornier, that was," or the back-seat driver's dream.

Variable-Incidence Wings

To avoid such happenings the machine illustrated was designed to facilitate the use of fixed rear guns without necessitating locking the forward controls. On this the wings are mounted on a transverse axis A and capable of a limited pivotal movement under the control of the "rearwardly looking" gunner without affecting the normal controls. By reducing the angle of incidence of the wing, as indicated in the dotted outline B, the gunner would increase the speed of the machine and, presumably, commence to lose altitude. Conversely, an increase of wing incidence angle would cause the machine to climb. It may be assumed that the pilot would take corrective action with the elevator control to restore his horizon, and consequently the effects would only be temporary. It is claimed as an advantage that the variation of wing incidence angle is only slight, and cannot be so readily observed by an attacking pilot as movement of the rudder and elevator.

It must not be presumed that the suggestion was made in a spirit of levity. The aircraft illustrated is a Dornier, and patents have been granted for the idea in Germany and in Britain (and possibly other countries) to Dornier-Werke G.m.b.H. and Dr. Ing. Claude Dornier, of Friedrichshafen.

In technical matters we endeavour to assess every idea solely on its merits and to free ourselves of any national pride or prejudice. With this disclaimer, we have no hesitation in recording our opinion that the British scheme is superior to the German one.

Scrap Paper Can Be Sold

OFFICES, factories, and other business or professional establishments which have scrap paper in bulk to contribute to the 100,000 tons urgently needed by the Government can, if they do not feel disposed to present it free to the country, sell it to an approved waste-paper merchant provided it is in sufficient quantity to justify collection—say, at least one ton.

An approved merchant is one licensed by the Paper Controller, and he will pay for the waste at schedule rates. Bulk waste can alternatively be disposed of to the local council, who will also collect it, but local authorities are not empowered to pay for waste.

If your business premises are in Bermondsey, however, you will surely prefer to co-operate with Mr. J. P. Mitchelhill, former proprietor of the Duchess Theatre, who has undertaken to pay to the R.A.F. Benevolent Fund £10 for every ton of paper collected during that borough's salvage week.

BARREL ENGINES

Part II of a Paper which Examines the Merits of the "Swashplate," the Cylindrical Cam, and the "Floating Wabbler"

By E. S. HALL

(Concluded from page 389.)

THE best way to avoid troubles caused by torque reaction on the wabbler is to refrain from putting torque reaction on the wabbler. J. O. Almen devised the "floating wabbler" to meet this condition. In its original form, it was used in the Model A-4 engine built at McCook Field (Fig. 6). While testing and development work on this engine were hardly more than started, a change in Army policy stopped the project before the excellence of the floating wabbler could be appreciated generally. The change in policy had nothing to do with the merits of the Almen engine, but was dictated by those who believed that developments of this sort should be done by private enterprise, and that the Government should not compete with the engine manufacturers.

The log and test data on the Model A-4 engine are still incomplete and unorganised; reports on Almen engines in the library at Wright Field refer to earlier engines. Tests, as far as completed, showed the mechanical efficiency of the wabbler mechanism to be higher than that of a crank mechanism, while the friction losses in the rotary valve system were higher than those in a comparable poppet-valve system. Under certain operating conditions, the wabbler was noisy; no control of the wabbler float axially on the wristpins had been provided. Based on the experience with the Model A-4 engine, the design for the Model A-5 was laid out (Fig. 7).

The superiority of this wabbler mechanism is obvious from its ability to run quietly at uniform output without any control of the wabbler float, demonstrating the absence of torque reaction on the wabbler. The wabbler is practically free from torque because the wristpin axes are maintained in the wabbler plane. Each wabbler arm is rotatable and slidable upon its wristpin. The wristpin carrier, like a trunk piston without head or rings, is rotatable and slidable in the bore through the piston. Every working surface of the wabbler is a surface of revolution about the wabbler axis or tangent to such a surface, so that essentially only friction forces can exert torque on the wabbler. The wabbler distributes the torque reaction among the several piston members without torque upon the wabbler itself.

With no direct operating loads tending to turn the wabbler, a suitable restraint for it is easy to provide. When running uniformly as an engine, no restraint is necessary; the stroboscope shows that the wabbler floats in the middle region of its freedom on the wristpins. It is held there by the summation of small components of wristpin pressure which act radially inward in the wabbler plane tending to centre the wabbler arms on the wristpins with enough effect to offset wabbler bearing friction. When operating conditions cause the predominating wristpin loading to occur after mid-stroke, as when the shaft tries to overrun the pistons, the summation of these small radial components may be outward, permitting the wabbler bearing friction to turn the wabbler to the limits of its freedom on the wristpins. This causes knocking of the

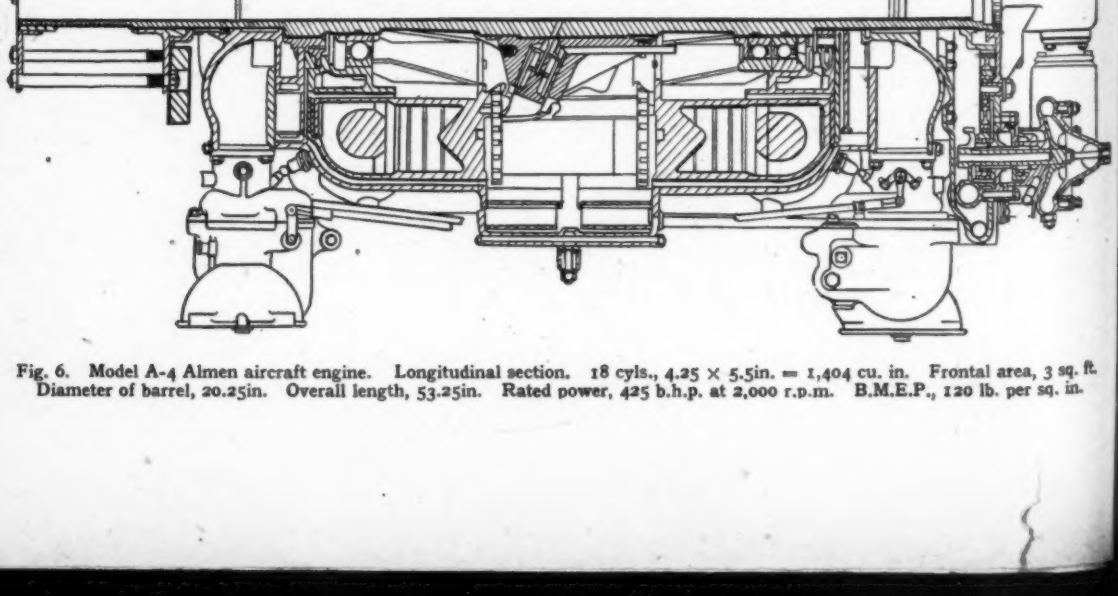
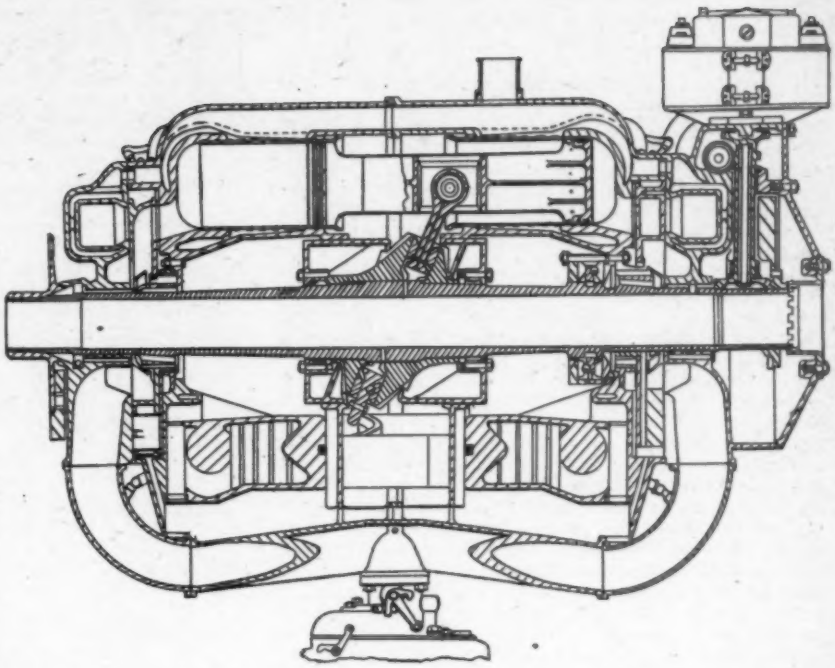


Fig. 6. Model A-4 Almen aircraft engine. Longitudinal section. 18 cyls., 4.25 × 5.5in. = 1,404 cu. in. Frontal area, 3 sq. ft. Diameter of barrel, 20.25in. Overall length, 53.25in. Rated power, 425 b.h.p. at 2,000 r.p.m. B.M.E.P., 120 lb. per sq. in.

Fig. 7. Model A-5 Almen aircraft engine design.



wabbler arms on the wristpin carriers if no wabbler restraint is provided.

Since only small forces are involved, any restraint can be made adequate for controlling the wabbler float. One arm may be locked axially on one of the wristpins, but this would necessitate twice the normal amount of axial freedom on arms 90 deg. removed, and the stroke motion of the several piston members would no longer be identical. It is better to use a restraint capable of maintaining correct wabbler motion, such as any uniform-velocity universal joint connecting the wabbler and the fixed parts of the engine, or certain forms of gearing. The way believed to be most satisfactory is to let the wabbler float, with cushions which come into play only when needed (Fig. 8). Cushions may be provided at little cost by forming the ends of the wabbler arm bushings as annular pistons to operate in counterbores in the wristpin carriers as dash pots, fed by oil from the pressure system trapping oil and air, passing the duty of preventing metal-to-metal contact from one to another 18 times per revolution with a wabbler having 9 arms.

Comparisons with Other Mechanisms

Bearing loadings in the floating wabbler mechanism are quite low. In a straight-through piston member the wristpin bearing may have twice the area used in current radial engines of the same bore. The main wabbler bearings have the heaviest loading; they carry the entire engine output. However, they are not burdened with useless centrifugal loading, so carry only one-quarter the loads which the master rod of a radial engine must carry. Plain journal bearings, spherically mounted, can be used on a Z-crank, but a straight tubular shaft is preferable to a Z-crankshaft. Ball or roller bearings can be used on a straight shaft (Fig. 8). The best wabbler bearing is believed to be the plain type, the wabbler riding on a circular swashplate, the bearing faces either spherical or plane. A collar thrust bearing cannot carry heavy loads efficiently because the bearing surfaces are parallel and there is no way for the oil film to wedge in, but in this case the load is not axial but a couple; the bearing surfaces are not parallel and the oil can wedge in to produce good film lubrication. Mounting the wabbler on a swashplate with flooded lubrication from within, promoted by the centrifugal effect of the swashplate, is the simplest and least expensive wabbler bearing. That it is satisfactory has not yet been demonstrated. However, slipper bearings, known to be practical and efficient with flooded lubrication, can be used in the wabbler if plain bearings do not come up to expectations. In any case, the specific loading on the wabbler bearing surfaces can be less than 400 lb. per sq. in., instead of more than 2,000 lb. per sq. in. as in the master rod of a radial engine.

The best wabbler mechanism is a cross-head type (Fig. 8). Straight-through piston members, the shortest possible in all barrel engines, are axially symmetrical and of ample strength and rigidity whether made in one piece or three. The bore through the piston member, in which the wristpin carrier operates, is radial to the shaft, so that no radial components of piston side thrust can exist. The only side loading on the piston member is the useful load, tangent to the shaft, the torque reaction, carried in the plane of its origin without beam loading on the piston member, the central portion of the piston forming a cross-head operable with pressure lubrication in the middle region of the cylinder tube as a cross-head guide. The pistons themselves are free to act as ring carriers; they cannot cock or slap; and the rings are always square with the cylinders. Because of the lemniscate, the pistons have a small amount of rotation during their reciprocation, just enough to discourage ring-sticking.

The piston stroke is symmetrical, but not quite harmonic.

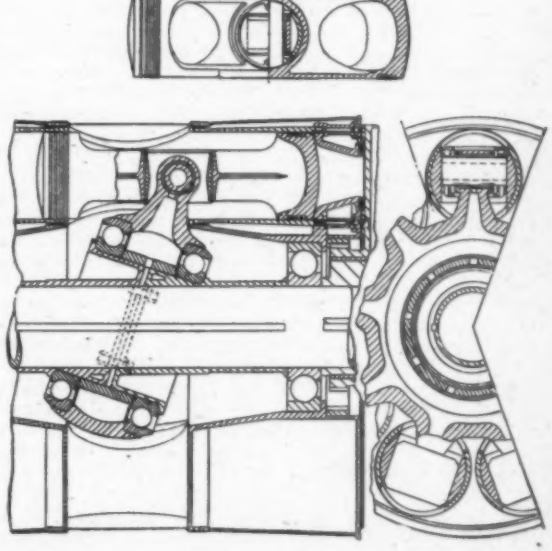


Fig. 8. Recent design of the floating wabbler mechanism with cushion control. Pistons are of the crosshead type, operating in one-piece cylinder sleeves, which serve as wet liners in both cylinder blocks.

BARREL ENGINES

The piston goes over centre more slowly than harmonic by an amount depending on the wabbler angle. Piston inertia forces peak about 8 per cent. less than with harmonic motion, instead of 25 per cent. more as in the crank mechanism, permitting correspondingly higher piston speed. Similarly, when time for combustion is the limiting factor, the shaft speed with the wabbler mechanism for a given combustion time can be 15 per cent. faster than with the crank mechanism.

The wabbler mechanism is not inherently balanced like the two-throw cylindrical cam mechanism, but the piston inertia forces form a couple of almost constant magnitude which can be counterbalanced quite well by a centrifugal couple. Instead of using heavy counterweights to fight the useless centrifugal loading on the master rod bearing, as in the radial, or a heavy swashplate as preferred by Michell, the counterweights in the wabbler mechanism can be spaced far apart, toward the ends of the shaft, and can be made of much less weight because of their long couple arms. The balancing loads on the main bearings may be correspondingly light and the stress path of the balancing forces in the cylinder blocks may be quite short, the piston inertia couple being impressed by the cylinder pressures on the cylinder heads while the centrifugal couple is impressed by main bearings substantially in the planes of the cylinder heads. The wabbler engine can operate smoothly without resort to wiggle weights or torsional dampers. Dynamic balance does not quite reach the perfection of that in the Michell-Crankless, but it is inherently close enough to perfection for practical purposes.

Barrel engines may be air cooled only by sacrifice of some of their compactness. Usually liquid cooling is preferred. The construction shown in Fig. 8 is desirable; cylinder sleeves extend from one cylinder head to the other, as wet liners in both cylinder blocks.

Combustion Systems for Barrel Engines

Having arrived at a barrel-engine mechanism better mechanically than the crank mechanism, what combustion system will make the most of its virtues? Those worth considering are: the familiar four-stroke cycle fed by a carburettor; and the two-stroke cycle with fuel injection. The two-stroke cycle with carburettor feed is ruled out by its poor economy. Four-stroke fuel-injection engines tend to be too heavy for aircraft and have little to recommend them aside from such personal reasons as the desire to use a pet combustion chamber, fondness for poppet valves, or the unwillingness to do the necessary development work to take advantage of the velocity and resonance in two-stroke exhaust. The choice is between four-stroke Otto cycle and two-stroke diesel, the latter term including all compression-ignition engines without hair-splitting as to the shape of their indicator cards. The choice must be made on merit. Which combustion system will give the lowest specific weight, greatest reliability, and best all-round performance in a barrel engine?

Four-stroke Gasoline Engines.—The policy of one new thing at a time dictates adaptation of four-stroke poppet-valve practice to the barrel engine. Concentric valve operating systems are possible, but congested. If the valves are to be inclined as in radial engines, the best way to drive them seems to be with individual camshafts coaxial with the cylinders (Fig. 9). Each camshaft and its rocker arms are mounted in a rocker box bolted to the plane face of the cylinder block. Rocker arms can be pivoted eccentrically with tappet adjustments readily accessible on the outside of the rocker box.

With a shaft for each cylinder, distribution of the coolant is easy by distribution of the water pumps, one pulling coolant from the radiator past each exhaust valve. Oil must be drained from the lower rocker boxes; why not put an oil pump on each camshaft, using part of them as scavenge pumps and the others for pressure, all internal engine oil lines being machined into the principal engine parts?

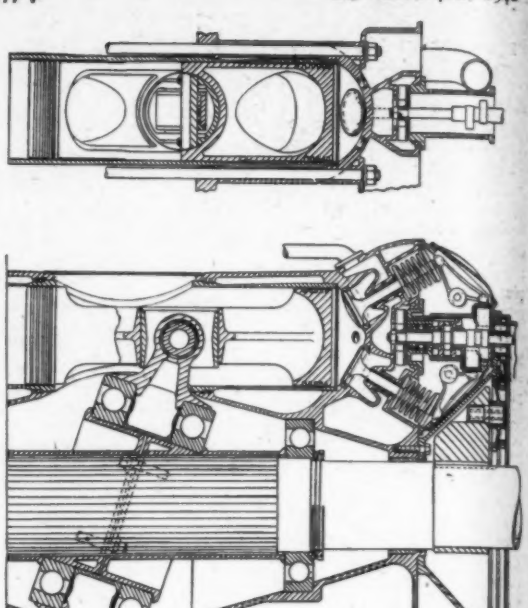


Fig. 9. Poppet valve layout with 18 camshafts, convenient as accessory drives. 18 cyls., 6.125 × 7in. = 3,712 cu. in. displacement.

Spark-plug accessibility in the through-bolt wells is about as good as usual, with spark-plug axes elements of the same cone on which the valve axes lie.

With 18 half-speed camshafts conveniently distributed around the ends of the engine, accessory driving is easy, and for the first time an aircraft engine had more accessory drives than the Army had use for. With attention to the problem of mixture distribution, and with the usual help from the gasoline makers, an engine of this type and size might be developed to deliver 3,000 b.h.p. at 3,000 r.p.m. with a b.m.e.p. of 214 lb. per sq. in. and a piston speed of 3,500 f.p.m. Weight would not be more than 2,700 lb. complete. Frontal area is 6 sq. ft.

The frontal area would be only 5 sq. ft., the weight a little less, and the production cost very much less, if a pair of Almen plate valves could be used in place of 36 poppet valves. Of course, it would be too bad to abandon the results of all the research work that had to be done to make poppet valves good enough for a high-performance engine, but one-tenth of that work applied to Almen plate valves would produce a valve system better adapted to the barrel engine. With rotary valve practice now available, the problems of the Almen valve seal, oil control, cooling, material and surface finish, deposits, and efficient support for the thrust—are capable of solution by any good research staff. The job is worth doing because of the enormous reduction in the number of bits in an aircraft engine, with correspondingly lower production time and cost.

More or Larger Cylinders?—To get more than 3,000 h.p. without another boost like 100-octane gasoline more displacement is needed. If cylinder size is limited by

(*a*) the impracticability of building a fire fast enough with two spark-plugs in a cylinder of much more than 200 cu. in.;
(*b*) the lower compression ratio required by the lower surface volume ratio of a larger cylinder;
(*c*) inability to cool the centre of a piston of much more than 6in. diameter;
(*d*) increasing reciprocating weights and higher bearing and piston friction;
(*e*) less volumetric efficiency with poppet valves in larger cylinders;

BARREL ENGINES

(*f*) inertia effects in poppet valve mechanism; and/or
(*g*) the principle of similitude which proves that a flock of small cylinders must weigh less per brake horse-power than few bigger cylinders of the same total displacement for a given piston speed;

then obviously, to get more displacement, one must use more cylinders or get rid of the limitations.

Use of more cylinders as the way to more power is fast approaching absurdity, out of reach of every cylinder arrangement except that of the corn-cob engine with its infinite multiplicity of cylinders and headaches—84 valves, 84 spark-plugs, in one engine, and presently 108 of each! In sane moments we can agree with three prominent engineers as reported by one of them in a recent letter:—

"Aircraft engines present to a higher degree than any other type of machinery the problem that failure of the entire machine may be caused by failure of a small part. Great sacrifice can be made in some respects to obtain simplicity in design. . . . No one will seriously question this view. . . . In the end it must mean very much less complex mechanisms than the industry in general is thinking of. I would not forget this point of view, for I believe it will ultimately point the direction of aircraft engine design."

Where the Diesel Scores

Turning from more cylinders as the way to more power to the aforementioned limitations of cylinder size, it is striking that all of them are limitations either of the four-stroke gasoline combustion system or of the crank and poppet-valve mechanisms. Larger cylinders, less attractive for burning gasoline for the reasons cited, the more attractive for compression-ignition. Diesel combustion is easier to control in a larger cylinder at somewhat slower shaft speed, with more time for combustion.

The principle of similitude cannot be applied between small cylinders operating on a cycle peculiarly adapted to them and larger cylinders operating on another cycle better suited to larger cylinders. Another joker in the similitude deck is that piston speed does not have to be "given." With only a small increase in piston speed with longer stroke, such as is easily possible with a good crosshead mechanism, the advantage of a flock of small cylinders evaporates, leaving the prospect of less weight per brake horse-power from fewer and larger cylinders.

Friction mean effective pressure chargeable to rings is less for a larger cylinder, since ring contact area increases substantially with the bore, while piston area increases with $(\text{bore})^2$. The piston speed limit imposed by increasing friction losses may be lifted by the cut in piston friction from the use of the crosshead. The double-ended piston member is too long to cock, and rings maintain good action at higher speeds when maintained squarely in working position. And the wabbler mechanism permits an increase in piston speed of 15 per cent. for the same combustion time. Add all these gains possible with the wabbler mechanism, and a speed of 4,000 f.p.m. = 3,000 r.p.m. with an 8in. stroke may be expected, especially in a normal barrel engine operating two-stroke, a unique combination which favours high mechanical efficiency and smoothness at higher speed than would be practicable in any other engine type.

Two-stroke Fuel-injection Engines.—The conservative policy here would be to follow Junkers practice. The barrel engine offers an easier way to build the opposed-piston engine. Two engine mechanisms can be mounted on the same shaft with their pistons facing each other in the same cylinders. This is a better way to use a proved combustion system, but it does not make the most of barrel-engine compactness, and the second reciprocating-rotary mechanism is a stiff price to pay for getting rid of cylinder heads. Pistons overrunning exhaust ports only will need liquid cooling before reaching the output we have in view,

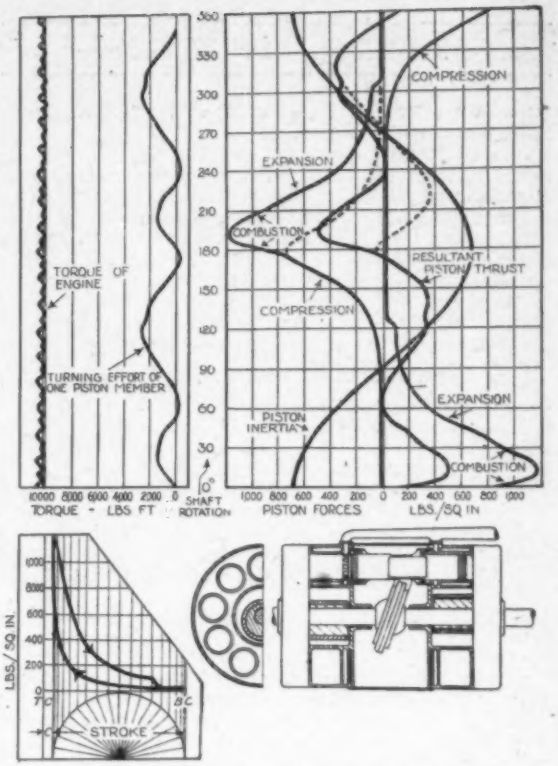


Fig. 10. Double-acting characteristics of a 3,000 h.p. 18-cyl. two-stroke barrel diesel by E. S. Hall, 1938. Piston inertia offsets peak cylinder pressures. Resultant piston thrust and turning effort have two moderate impulses per stroke, every stroke. The engine torque curve shows 36 impulses per revolution from 18 cylinders, with a variation from mean torque of less than ± 3 per cent.

and injector location on a combustion chamber between pistons is not all that could be desired. However, the principal reason for not using opposite pistons is that mechanical conditions in the normal two-stroke barrel engine can be so very much better.

Essentially Double-acting

In the normal barrel engine, with double-ended piston members operating two-stroke at both ends, the engine is essentially double-acting. Piston inertia at every stroke serves the useful flywheel function of offsetting cylinder peak loadings to smooth out the torque curve instead of adding to bearing loadings and friction losses as in opposed-piston and crank engines. For example, in Fig. 10, the indicator card at the lower left is rougher than need be expected in a two-stroke diesel with maximum pressure 1,180 lb. per sq. in. At the upper right the same pressures are plotted on a time basis for one revolution at both ends of the piston member. The pistons were given plenty of metal for good heat flow and to provide enough mass to develop inertia force at cruising speed, peaking somewhat more than half the maximum gas pressure. Inertia peaks are always opposite the gas-pressure peaks, and the resultant piston thrust has two moderate impulses per stroke, every stroke.

Of these two power impulses in each stroke the primary is the greater, 500 lb. per sq. in., about equal to the maximum loading in an automobile engine, but the secondary impulse is more effective in producing torque because it occurs soon after mid-stroke when the mechanical advantage of the pistons in turning the shaft is best. The engine torque curve shows 36 impulses per revolution from 18 cylinders, with a variation of less ± 3 per cent. from the

BARREL ENGINES

mean—the smoothest torque curve so far plotted for an internal-combustion engine.

Piston and shaft speeds can be higher in an engine designed to take advantage of this double-acting condition. Expansion at one end can do the work of compression at the other end of the same piston member. Almost no negative work need be done by the mechanism on the pistons. The piston can bounce back and forth between opposing gas pressures as fast as the combustion can be handled, and the combustion can be handled at 15 per cent. higher shaft speed than in a crank engine because the pistons go over centre more slowly than the wabbler.

Peak Pressures and Piston Inertia

High maximum cylinder pressures of the diesel cycle (which actually need be no higher than now tolerated in supercharged gasoline engines) are not so objectionable when they can be cut down to reasonable size by piston inertia before they reach the mechanism. Enough strength must be provided to take heavy combustion pressures which might occur at slow speed before piston inertia has built up, so that, during normal operation, the mechanism is understressed, making for dependable, long life.

Add together:

this double-acting characteristic and other factors which permit 15 per cent. to 25 per cent. higher piston and shaft speeds;

plus the simplicity and somewhat better mechanical and thermal efficiencies of fewer and larger cylinders;

plus the two-stroke cycle which can push the piston three-fourths as hard twice as often for a net gain in h.p. per cu. in. of 50 per cent.;

plus the inherent compactness of the barrel-engine type which takes so little metal to surround so much displacement;

and the answer = diesel aircraft engines weighing less than 1 lb. per h.p.

The normal barrel two-stroke diesel weighing less than 1 lb. per h.p. can be built in one of several different ways. Choice of breathing system and other details must, however, be governed not only by their excellence but also by the way they fit into the barrel-engine picture. Certain simple forms of valving and the most advantageous application of the turbo-blower are possible only with the parallel-cylinder arrangement. Unit fuel injectors also are applied readily and, together with open combustion chambers, are demanded by the high performance desired.

Uniflow scavenge is best obtained by using piston-controlled intake ports with valves in the head. Conditions may be too severe for poppet valves. Even though diesel exhaust were cooler, would you ask the best valves available to pop twice as often and seat half as long? Possibly four valves operating in pairs, four-stroke, could be arranged.

The sleeve valve, operating almost in time with the piston on a stroke about half as long, has a telescopic effect, permitting a surprisingly short engine—48in. over the cylinder heads with an 8in. stroke.

Holding high pressures in a diesel cylinder can be made somewhat simpler if confined to the seal of the piston in the cylinder by using an integral cylinder barrel and head, with port scavenging. Rings running over exhaust ports are not desirable, but "great sacrifice can be made in some respects to obtain simplicity in design." To get effective loop scavenge it is necessary to control the effective port opening and closing either by a delay valve outside the intake ports, or a cut-off valve outside the exhaust ports, or both. Valves for these purposes need not seal tightly and are easier to provide and drive with the convenient parallel arrangement of the cylinders.

The best breathing and combustion system for the normal two-stroke barrel diesel is being determined by comparative study and experience, results of which may be discussed with interested and responsible parties. The port-scavenged engine may be the easiest to start with, but one of the uniflow types may prove best in the end. What sort of performance, bulk, and weight can be expected?

For plenty of power, the easier way is to start with enough piston displacement.

18 cyl. 7×8in. = 5,540 cu. in. displacement.

Outside diameter of the engine = $3S + B + 5$in. = 36in. Frontal area, 7 sq. ft.

Length of the power section of the engine = 48in.

Weight of this power section, 3ft. diameter × 4ft. long, 2,300 lb.

Weight of reduction gear, centrifugal blowers, and accessories, 1,000 lb.

Total weight, 3,300 lb.

Without too much development work, a b.m.e.p. of 80 lb. per sq. in. with a piston speed of 2,000 f.p.m. at 1,500 r.p.m. could be expected:

$$1{,}680 \text{ h.p.} = \frac{80 \text{ lb. sq. in.} \times 5{,}540 \text{ cu. in.} \times 1{,}500 \text{ r.p.m.}}{12 \times 33{,}000}$$

This would make a good railroad and marine engine. The Navy could use an engine weighing 2 lb. per h.p. and taking up one-fourth the room required for the best diesel of similar power now available.

If we can learn how to design and specify materials for such an engine, the weight might be trimmed to 3,000 lb. complete. Develop the best breathing and combustion systems and, in due course, the b.m.e.p. can be shoved up to 120 lb. per sq. in. (less than two-thirds that now current practice in four-stroke gasoline engines) with piston speed 4,000 f.p.m. at 3,000 r.p.m. (equivalent to about 2,500 r.p.m. with the crank mechanism):

$$5{,}040 \text{ h.p.} = \frac{120 \text{ lb. sq. in.} \times 5{,}540 \text{ cu. in.} \times 3{,}000 \text{ r.p.m.}}{12 \times 33{,}000}$$

There it is—5,000 h.p.—3,000 lb.—7 sq. ft. frontal area. That order of performance can be had most easily by working along these lines.

Empire Trained Pilots in Malaya

PILOTS trained under the Empire Training Scheme in Australia, Canada and Britain are now serving in Malaya.

One of the latest squadrons formed in the Far East includes members of the Royal Australian Air Force. This squadron, which flies Buffaloes, is known as an infiltration squadron. It operates under R.A.F. conditions of service, but is attached to a station manned by the R.A.A.F. Its Australian members are entitled to wear R.A.F. uniform.

The squadron commander and two flight commanders fought in daily R.A.F. sweeps over the Continent. The squadron commander, a 24-year-old Englishman, was a member of a Spitfire squadron in England from the outbreak of war until he was transferred to Malaya. He is the only non-Australian in the new squadron.

The flight commanders were two of the first pupils at Wagga, the first Empire Training Scheme school established in Australia. They have flown Spitfires and Hurricanes, but are satisfied that the Buffalo is capable of outclassing any opposition it is likely to meet in the Far East.

Mine Host Mace

THERE are few of the older members of the aircraft industry who have not met Mr. W. H. Mace, at one time works manager of Hawkers and later of Folland Aircraft. Mr. Mace went to the M.A.P. early in the war, but after a time his nerves played him up, and his doctor ordered a complete rest. His many friends will be interested to learn that Mr. Mace now presides at the Prince of Wales Hotel, Holcombe Rogus, Taunton, where he is benefiting from a peace and quiet which contrasts strongly with his previous work. Mr. Mace hopes ultimately to return to the industry which he knows so well, but in the meantime he would be pleased to hear from his old friends, and if any of them should be down Zomerzet way, they would receive a hearty welcome at Holcombe Rogus.

HERE AND THERE

Aircraft and Art

THOSE who have a liking for coloured prints of R.A.F. machines in flight will find much to attract them in the series now being published by Brownlee Studios, Ltd., Manor House, 21, Soho Square, London, W.1. This comprises two by C. R. W. Nevinson and Norman Wilkinson, in both of which the aircraft are really incidental to the picture as a whole, and three by Allen Mold and two by G. H. Pooley, in which the sea, land or skyscape is an artistic background for the aircraft.

The publishers state that although technical accuracy cannot be guaranteed, each picture has been submitted to the Ministry of Aircraft Production for scrutiny under this heading.

The prints, all of which have margins for framing, are in three different sizes and are priced from 12s. 3d. to 21s. each.

Similar pictures in the form of greeting cards are also available.

Part of Their Service

ROYAL DUTCH AIR LINES and Royal Netherlands Indies Airways—more briefly known under their Dutch initials of K.L.M. and K.N.I.L.M. respectively—who are keeping the civil aviation flag flying between Palestine and Australia, have just issued their latest time-tables and fare schedules, complete with colourful maps, which are all very provocative to the besieged Briton these days.

An interesting item appears in the information for passengers: it is that "passengers travelling long distances are supplied with two special lightweight suit cases, which remain the property of the passenger." But the very reasonable proviso is made (for the benefit of those who travel frequently) that one is only entitled to one set of these suit cases per year.

AWAITING DESPATCH: A scene inside one of the many underground bomb stores dotted around the countryside.

Wrought Light Alloys in Wartime

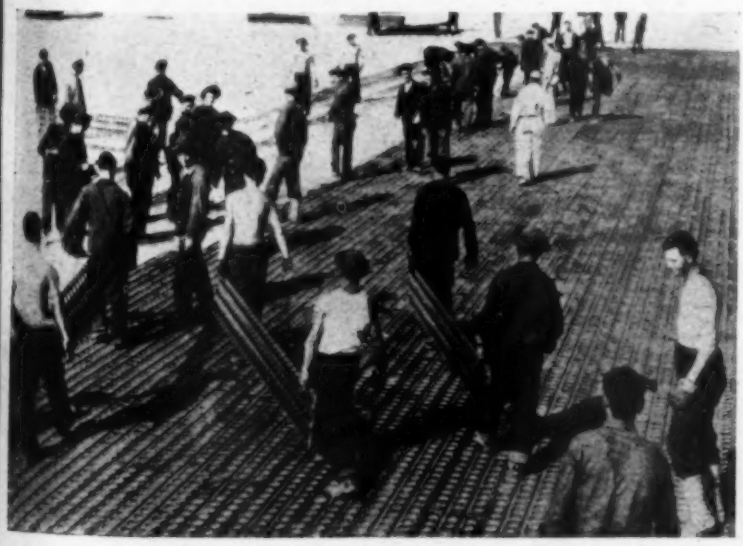
FORMED primarily to increase the application of wrought light alloys, the Wrought Light Alloys Development Association has adopted as its wartime policy the dissemination of all available data on the properties and working of these materials and has set up an Advisory Service Bureau for this purpose.

The Association, which comprises the principal makers of such alloys in this country, places its services, free of charge, at the disposal of any fabricators or users of aluminium alloys who may have problems that cannot be solved in their own works. They intend also to prepare a series of booklets dealing with the practical aspects of light alloy treatment and manipulation.

Enquiries should be sent to their consultant manager, Dr. E. G. West, at the Association's office at 34, New Street, West Bromwich, Staffs, and should include full details of the material, the operation concerned, and any measures already tried. Samples should accompany enquiries whenever possible.

ADVERTISED GOODS

THE fact that goods made of raw materials in short supply owing to war conditions are advertised in this journal should not be taken as an indication that they are necessarily available for export.



Rumour Dispelled

REPORTS of foreign aircraft seen flying over Canada's northland are completely groundless, Royal Canadian Air Force headquarters authorities state. The only aircraft of a "foreign" power that have flown over Canadian territory since the war began are those of the United States.

Stories of strange or foreign-looking aircraft have all been carefully investigated, and in every case it proved to be a Canadian or American machine.

The Government vessel, the S.S. *Nascopie*, has just returned from a lengthy journey to northern points, and the ship's company reported nothing untoward in those regions.

Incidentally, Canada has a civilian aircraft detection corps, which has already demonstrated its efficiency, and which would quickly notify the proper authorities if any strange aircraft were seen.

AIRFIELDS WHILE YOU WAIT: Combat engineers of the U.S. Army laying out a portable runway made of metal gratings.

Service Aviation

An Oxford waiting by the flare path for the take-off signal.

Royal Air Force and Fleet Air Arm News and Announcements

Awards

Fleet Air Arm

THE KING has given orders for the following appointments and awards for courage and resolution in operations in Mediterranean waters:

DISTINGUISHED SERVICE ORDER.

Lt. Cdr. (A) J. S. DOUGLAS, R.N., H.M.S. *Ark Royal.*

Temp. Lt. (A) R. C. COCKBURN, R.N.V.R., H.M.S. *Ark Royal.*

DISTINGUISHED SERVICE CROSS.

Temp. Lt. (A) G. C. McE. GUTHRIE, R.N.V.R., H.M.S. *Ark Royal.*

DISTINGUISHED SERVICE MEDAL.

Pet/O. Airman W. E. CUTTRISS, H.M.S. *Ark Royal.*

Royal Air Force

THE KING has been graciously pleased to approve the following awards in recognition of gallantry and devotion to duty in the execution of air operations:—

The number after each name represents the squadron with which the recipient was serving at the time of the award.

DISTINGUISHED SERVICE ORDER.

Act. Flt. Lt. E. E. COLLINS, D.F.M., No. 50.

BAR TO THE DISTINGUISHED FLYING CROSS

Act. Sqn. Ldr. J. D. WARNE, D.F.C., No. 58.

DISTINGUISHED FLYING CROSS.

Act. Grp. Capt. H. V. SATTERLEY, No. 83.
Wing Cdr. A. V. SAWYER, No. 78.
Sqn. Ldr. R. S. J. EDWARDS, No. 9.
Sqn. Ldr. M. V. PETERS-SMITH, No. 57.
Sqn. Ldr. R. D SPEARE, R.A.F.O., No. 7.
Act. Sqn. Ldr. A. W. HIRONS, R.A.F.V.R., No. 49
Act. Sqn. Ldr. J. H. KYNOCH, No. 83.
Flt. Lt. R. G. WILBERFORCE, R.A.F.V.R., No. 9.
Act. Flt. Lt. S. C. R. BELL, No. 144.
Act. Flt. Lt. H. W. H. FISHER, No. 49.
Act. Flt. Lt. T. A. FOX, No. 50.
Act. Flt. Lt. R. HILTON, R.A.F.V.R., No. 214.
Act. Flt. Lt. J. C. McWATTERS, R.A.F.V.R., No. 78
F/O. R. B. OSBORN, R.A.F.V.R., No. 99.
F/O. K. G. TEW, R.A.F.V.R., No. 44 (Rhodesia).
F/O. P. R. TURGEL, No. 144.
P/O. D. J. BELL, R.A.F.V.R., No. 44 (Rhodesia).
P/O. L. A. BRAIN, R.A.F.V.R., No. 220.
P/O. E. C. COX (R.N.Z.A.F.), No. 57.
P/O. W. I. DEAS, R.A.F.V.R., No. 61.
P/O. D. B. FALCONER, R.A.F.V.R., No. 49.
P/O. D. R. O. FORD, R.A.F.V.R., No. 50.
P/O. H L. HOLLIDAY, R.A.F.V.R., No. 214.

The crest of No. 609 (West Riding) Auxiliary Air Force squadron which was presented recently by Air Commodore Harald Peake, Director of Public Relations. It depicts two hunting horns surmounted by the White Rose of Yorkshire.

P/O. P. R. HUGHES, R.A.F.V.R., No. 99.
P/O. W. L. JENNINGS, R.C.A.F., No. 57.
P/O. J. Y. MALLEY, R.A.F.V.R., No. 149.
P/O. D. L. MATTHEWMAN, R.A.F.V.R., No 51.
P/O. L. W METCALFE, R.A.F.V.R., No. 61.
P/O. E. H. O'NEILL, R.A.F.V.R., No. 57.
P/O. L. A. RICKINSON, No. 101.
P/O. K. E. ROBINSON, R.A.A.F., No. 9.
P/O. J. E. SWIFT, R.A.F.V.R., No. 57.
P/O. R. H. WATTS, No. 50.
P/O. T. J. W. WILLIAMS, R.N.Z.A.F., No. 75 (N.Z.)

DISTINGUISHED FLYING MEDAL.

Flt. Sgt. H. J. ARCHER-CRUMP, No. 101.
Flt. Sgt. G. CROMBIE, R.A.F.V.R., No. 144.
Flt. Sgt. J. A. RICH, R.A.F.V.R., No. 142 (Since killed.)
Flt. Sgt. H. J. SPILLER, No. 12.
Sgt. D. P. D. ARCHER, R.A.F.V.R., No. 102.
Sgt. M. B. BERNDSSON, R.A.F.V.R., No. 102.
Sgt. F. W. CHRISTIE, A.A.F., No. 50.
Sgt. T. J. DANIELS, No. 144.
Sgt. S. R. DAWSON, R.A.F.V.R., No. 50.
Sgt. A. C. H. DENNIS, No. 83.
Sgt. A. DICKINSON, R.A.F.V.R., No. 83.
Sgt. H. DOBBS, A.A.F., No. 44 (Rhodesia).
Sgt. E. C. DUKE, No. 51.
Sgt. K. W. DUNLOP, R.A.F.V.R., No. 144.
Sgt. C. J. FARMERY, R.A.F.V.R., No. 10.
Sgt. L. FISH, No. 77.
Sgt. A. FRANCIS, No. 51.
Sgt. S. R. FROST, No 57.
Sgt. J. GARNETT, No. 405 (R.C.A.F.).
Sgt. D. N. GRAINGER, R.A.F.V.R., No. 83.
Sgt. C. H. HATWOOD, No. 9.
Sgt. A. D. HEARD, No. 58.
Sgt. J. A. HODGKINSON, R.A.F.V.R., No. 61.
Sgt. W. M. JAMIESON, No. 51.
Sgt. L. G. LEWIS, A.A.F., No. 12.
Sgt. J. O. LITTLE, No. 405 (R.C.A.F.).
Sgt. D. MACCULLUM, A.A.F., No. 83.
Sgt. W. F. MCMASTER, R.A.F.V.R., No. 68 (R.C.A.F.).
Sgt. H. MASON, No. 103.
Sgt. T. A. MATTHEWS, No. 77.
Sgt. R. E. MOORE, No. 50.
Sgt. R. T. PADDEN, R.A.F.V.R., No. 61.
Sgt. J. PAYNE, R.A.F.V.R., No. 144.
Sgt. F. E. RYMILLS, R.A.F.V.R., No. 58.
Sgt. L. F. SANDFORD, No. 77.
Sgt. F. C. SERGENT, R.N.Z.A.F., No. 57.
Sgt. S. J. SHORT, No. 51.
Sgt. A. R. SIMMONS, No. 144.
Sgt. A. G. SMITH, No. 49.
Sgt. D. N. SMITH, R.A.F.V.R., No. 144.

Sgt. K. J. STANFORD, R.N.Z.A.F., No. 57.
Sgt. H. A. TAYLOR, No. 57.
Sgt. R. G. TREE, R.A.F.V.R., No. 49.
Sgt. F. C. WEBB, R.A.F.V.R., No. 51.
Sgt. J. WILLIAMS, No. 104.
Sgt. L. A. F. WILMOT, R.A.F.V.R., No. 144.
Sgt. V. E. WOOLNOUGH, No. 144.

Sgt. G. M. MASON, R.A.F.V.R., No. 101 Squadron.—One night in October, 1941, this airman was the navigator of an aircraft which was detailed to attack Bremen. Weather conditions were extremely unfavourable, making it impossible to accomplish the original mission, but Sgt. Mason skilfully directed his pilot to an alternative target. In spite of intense anti-aircraft opposition, bombs were dropped over the target area, and very large fires were seen by the crews of other aircraft.

Sgt. Mason has completed 50 sorties, including both day and night attacks against important enemy targets. He is an exceptionally good observer, whose courage and determination have set an excellent example.

Sgt. H. RAMSEY, No. 220 Squadron.—This airman has carried out 450 hours' operational flying, involving patrols, convoy escorts and numerous successful attacks on enemy shipping. In October, 1941, he participated in a highly successful raid on shipping and obtained direct hits on one of the enemy's vessels from a height of only 20 feet. Violent explosions occurred inside the ship, causing a burst of flame and portions of the deck to be hurled into the air. Sgt. Ramsey has at all times pressed home his attacks with the greatest determination.

Sgt. A. WELDON, No. 150 Squadron.—This airman has participated in 19 operational flights, on 16 of which he has acted as a gunner and on three as first wireless operator. During a recent raid on Mannheim the aircraft in which he was flying as first wireless operator was hit by shell-fire. The rear turret and the back of the fuselage became filled with smoke from smouldering or burning fabric.

Sgt. Weldon assisted the rear gunner, who had been injured, from the turret, and commenced to beat out the fire with his hands, finally putting it out with an extinguisher which was passed to him. He then endeavoured to get the damaged turret to function, but, as it had become jammed, his efforts were unavailing. He therefore returned to his wireless duties and reported the situation to his captain. The whole of this work was carried out whilst the aircraft was flying at 16,000 feet in a temperature of −25 deg., and without a supply of oxygen. Sgt. Weldon has always set a good example

Six pilots of the R.A.F. who are now lecturing in the United States. Left to right (standing) Wing Cdr. A. G. Malan, D.S.O. and Bar, D.F.C. and Bar; Group Capt. H. Broadhurst, D.S.O., D.F.C., A.F.C.; Wing Cdr. R. S. Stanford Tuck, D.S.O., D.F.C. and two Bars. (Seated) Wing Cdr. J. N. H. Whitworth, D.S.O., D.F.C.; Group Capt. J. N. Boothman, A.F.C.; Wing Cdr. H. I. Edwards, V.C., D.F.C.

Roll of Honour

Casualty Communique No. 93.

THE Air Ministry regret to announce the following casualties on various dates. The next-of-kin have been informed.

Royal Air Force

KILLED IN ACTION (WHILE FLYING IN OPERATIONS AGAINST THE ENEMY).—Sgt. M. R. Day; Sgt. F. Filmer.

PREVIOUSLY REPORTED MISSING, BELIEVED KILLED IN ACTION, NOW PRESUMED KILLED IN ACTION.—Sgt. D. W. Banham; P/O. D. V. Bingham-Hall; Wing Cdr. W. E. Cameron; P/O. S. G. Collier; Sgt. A. V. M. Farns; Sgt. W. W. Fox; Sgt. E. Freeman; Sgt. N. A. Geer; Sgt. W. J. Howlett; Sgt. E. Lawley; Sgt. J. M. McAlonan; Sgt. J. Mingham; Sgt. H. E. Postill; P/O. D. E. F. Powell; Sgt. W. Powell; Sgt. E. Richardson; Sgt. P. A. Savage; Sgt. J. S. Shaw; Sgt. R. C. Smith; Sgt. J. H. Spatchett; Sgt. L. Stewart; Flt. Sgt. R. S. Stories; Sgt. J. F. J. Taylor.

PREVIOUSLY REPORTED MISSING, NOW PRESUMED KILLED IN ACTION.—Wing Cdr. D. Addenbrooke; Sgt. I. J. Adey; P/O. E. A. Alexander; P/O. S. L. Bailey; Sgt. R. W. Baker; Sgt. C. H. Bell; Sgt. N. Benfield; Sgt. E. E. Blomeley; P/O. F. E. Bryant; Sgt. A. Coates; Sgt. E. Cottingham; P/O. G. Davies; Sgt. A. C. H. Edmeads, P/O. R. Edwards, P/O A. A. Florigny, Sgt. W. A. Foster, Act. Flt. Lt. A. E. R. Fry, D.F.C.; P/O. A. C. Geary; Sgt. C. B. Harrison; Sgt. H. T. Hellier; Sgt. A. C. Hoare; Sqn. Ldr. A. T. Irvine; P/O. D. H. M. Jack; P/O. A. E. Jackson, D.F.M.; Sgt. L. J. Kennard; Sgt. E. K. Lindsay; Sgt. L. P. MacDowell; P/O. J. McIntosh; Sgt. H. D. McNabb; P/O. W. A. McVie; P/O. W. K. Manifould; Sgt. B. M. Mansfield; Sgt. R. Mecoh; Sgt. W. E. Moore; Sgt. W. D. Morrison; Sgt. K. R. Northwood; Sgt. J. T. Owen; Sgt. V. S. Payne; Sgt. E. G. W. Perkins; P/O. A. F. Phillips; P/O. E. W. Reynolds, Sgt. F. Sherratt, P/O. R. W. Shrewsbury; P/O. J. Still; Act. Flt. Lt. R. E. Tallis; P/O. D. F. R. Whyte; Sgt. P. H. Woodbridge; Sgt. C. J. Woods.

WOUNDED OR INJURED IN ACTION.—P/O. A. Aldridge; Sgt. F. Scrivens.

MISSING, BELIEVED KILLED IN ACTION.—P/O. D. U. Barnwell, D.F.C.; Sgt. E. T. Christie; Sgt. E. W. Ireland; Sgt. G. W. T. Jackson; F/O. R. James, D.F.C.; Sgt. D. W. Jennings; Sgt. E. S. Jones; Sgt. N. J. Lewery; Flt. Lt. L. F. Malone, D.F.C.; Sgt. J. D. Pugh; Sgt. H. G. Sloman; Sgt. R. W. Toller; Sgt. K. H. Toothill.

MISSING.—Sgt. C. W. Almond; Sgt. R. E. Arnold; F/O. L. L. Bache; Sgt. R. G. Banks; Sgt. D. Beal; Sgt. W. B. Billingsley-Dooley; Sgt. E. Brayley; Sgt. C. J. S. Buckle; Act. Flt. Lt. R. J. Chamberlain, D.F.C.; Sgt. F. W. Church; P/O. H. M. Clarke; Sgt. W. A. C. Dickenson; Sgt. W. H. A. Everson; P/O. G. A. O. Gordon; Sgt. G. A. Highfield; P/O. R. C. Holloway; Sgt. F. L. C. Jewell; Sgt. P. R. Martin; Sgt. F. Morris; Sgt. G. S. Needler; Sgt. C. H. B. Page; Sgt. S. L. T. Paine; F/O. T. R. Paxton; Sgt. D. G. Peppler; Sgt. D. Poulston; Sgt. F. H. M. Rodmer; P/O. T. R. Ruxton; Sgt. E. K. Saul; P/O. M. M. Sherley-Price; Sgt. A. D. Shuckburgh; Sgt. V. F. W. Slade; A/C.2 G. S. Sinclair; A/C.2 A. W. Smith; Sgt. H. Tattersfield; Sgt. M. F. Tomkins; Sgt. D. H. Warden; Sgt. C. E. White; Sgt. W. J. S. Wolstenholme.

MISSING, BELIEVED KILLED ON ACTIVE SERVICE (WHILE ENGAGED ON NON-OPERATIONAL FLYING DUTIES OR ON THE GROUND THROUGH ENEMY ACTION).—P/O. D. A. F. Allmond; Sqn. Ldr. P. C. Rolt.

KILLED ON ACTIVE SERVICE.—Sgt. W. J. Anstey; P/O. R. H. Atkinson; Act. F/O. R. M. Bagshaw; Sgt. A. J. Beard; Act. Wing Cdr. D. P. A. Boitel-Gill, D.F.C.; Sgt. R. Brady; Sgt. T. C. Bramley; P/O. P. Chubb; L.A/C. J. L. Coen; Sgt. J. M. Coxon; F/O. W. H. Dimmock; Flt. Sgt. J. S. Fisher; P/O. I. R. Fyfe; L.A/C. D. C. Goymer; A/C.2 H. N. Gray; Sgt. E. J. H. Heather; L.A/C. P. Hedley; Sgt. A. Hildebrandt; Sgt. L. Hunt; Sgt. J. W. Kerrison; L.A/C. N. Lamb; Sgt. S. D. Lee; F/O. S. McAllister; Sgt. R. McNamara; Sgt. J. Manby; Sgt. G. P. Phitides; L.A/C. E. W. Pierce; Sgt. F. E. Postlethwaite; P/O. J. E. Robson; L.A/C. W. E. Soady; P/O. D. McD. Steven; L.A/C. D. R. W. Stiven; L.A/C. S. Sunderland; P/O. K. R. Swann; Sgt. F. W. Treeby; Act. Wing Cdr. T. J. L. Watkins; Sgt. B. L. Woodfield; Sgt. N. T. Woscncroft; Sgt. S. Yates; L.A/C. J. A. S. Yonge.

PREVIOUSLY REPORTED MISSING, BELIEVED KILLED ON ACTIVE SERVICE, NOW PRESUMED KILLED ON ACTIVE SERVICE.—Sgt. D. S. Birtwhistle; Sgt. G. H. Vickers.

Air Vice-Marshal H. Edwards, who has arrived in London to assume the post of A.O.C. Royal Canadian Air Force in England. With him are Group Capt. W. A. Curtis and Wing Cdr. W. C. H. Fowler.

SERVICE AVIATION

PREVIOUSLY REPORTED MISSING, NOW PRESUMED KILLED ON ACTIVE SERVICE.—Sgt. F. W. Corder; A/C.2 R. Shepherd; A/C.2 J. Staunch; A/C.1 L. A. Watchous.

PREVIOUSLY REPORTED MISSING, BELIEVED KILLED ON ACTIVE SERVICE, NOW REPORTED KILLED ON ACTIVE SERVICE.—Flt. Lt. F. Austin.

WOUNDED OR INJURED ON ACTIVE SERVICE.—Sgt. E. F. Bing; Sgt. J. E. Burrell; L.A/C. R. Gray; P/O. R. A. Hobbs; L.A/C. V. L. B. Jones; Sgt. D. E. Love; L.A/C. A. J. Muir; P/O. B. O. Smith; Cpl. G. Smith; L.A/C. T. P. Walsh; ... R. F. Whitehorn.

DIED OF WOUNDS OR INJURIES RECEIVED ON ACTIVE SERVICE.—Sgt. A. Southwood.

DIED ON ACTIVE SERVICE.—A/C.1 E. G. H. Alderton; L.A/C. J. M. Birse; Sgt. J. Ferguson; A/C.2 D. S. Foulger; A/C.1 D. Harling; Sgt. J. Hughes; L.A/C. H. Lidington; A/C.2 A. Magee; A/C.1 X. C. Mitchell; Cpl. E. H. G. Russell; A/C.2 K. E. Youngman.

PREVIOUSLY REPORTED MISSING, BELIEVED KILLED ON ACTIVE SERVICE, NOW REPORTED PRISONER OF WAR.—A/C.1 D. W. Gibson; L.A/C. J. B. Steedman.

PREVIOUSLY REPORTED MISSING, NOW REPORTED PRISONER OF WAR.—A/C.1 A. Bell; Sgt. J. A. Canning; A/C.1 I. P. Evans; Flt. Sgt. T. R. Green; A/C.2 S. Griffith; Cpl. F. E. Gulley; A/C.2 A. J. Harding; P/O. H. Mann; L.A/C. C. A. M. Nichols; Cpl. J. H. Palmer; L.A/C. A. F. W. Pearson; A/C.1 H. A. Ralph; A/C.2 G. H. Said; A/C.2 A. H. Schofield; A/C.1 A. Thorpe; Cpl. K. E. Wake; Sgt. A. D. Watt; L.A/C. J. O. Weston; Sgt. H. Wilkinson; Sgt. R. M. Williams.

Royal Australian Air Force

DIED OF WOUNDS OR INJURIES RECEIVED IN ACTION.—Sgt. J. E. Turner.

MISSING, BELIEVED KILLED IN ACTION.—P/O. K. J. Miller; Sgt. R. W. Stephenson.

MISSING.—Sgt. C. S. Balzer; P/O. R. M. Hudson; Sgt. E. P. Jackson; Sgt. R. J. Young.

KILLED ON ACTIVE SERVICE.—Sgt. E. H. Brenton; P/O. B. F. P. Corbet-Thompson.

WOUNDED OR INJURED ON ACTIVE SERVICE.—P/O. T. E. Wade.

PREVIOUSLY REPORTED MISSING, NOW REPORTED PRISONER OF WAR.—Sgt. T. B. Comins; P/O. A. Mackay.

Royal Canadian Air Force

WOUNDED OR INJURED IN ACTION.—Sgt. J. D. Carmichael; Sgt. H. P. Edworthy; Sgt. D. C. Martin.

MISSING.—Sgt. W. H. Davidson; Sgt. H. L. Elliot; Sgt. E. B. Muttart.

KILLED ON ACTIVE SERVICE.—Sgt. W. L. Falardeau; Sgt. B. I. Heese; Sgt. G. P. Parker; P/O. F. Redfern.

WOUNDED OR INJURED ON ACTIVE SERVICE.—Sgt. D. F. Allen; Sgt. J. G. O. Dufort; Sgt. W. E. Martin.

DIED ON ACTIVE SERVICE.—P/O. R. M. W. Gosnell.

PREVIOUSLY REPORTED MISSING, NOW REPORTED PRISONER OF WAR.—Sgt. C. E. McDonald.

Royal New Zealand Air Force

PREVIOUSLY REPORTED MISSING, NOW PRESUMED KILLED IN ACTION.—P/O. A. J. Falconer; P/O. A. V. Muir.

MISSING, BELIEVED KILLED IN ACTION.—Sgt. J. A. Ward, V.C.

PREVIOUSLY REPORTED MISSING, NOW REPORTED KILLED ON ACTIVE SERVICE.—Sgt. C. B. Barton.

South African Air Force

WOUNDED OR INJURED ON ACTIVE SERVICE.—Cpl. MacDonald; A. S. Tasker.

DIED ON ACTIVE SERVICE.—Lt. F. McLeod; Air Sgt. G. W. Masencamp.

Casualty Communique No. 94.

Royal Air Force

KILLED IN ACTION (WHILE FLYING IN OPERATIONS AGAINST THE ENEMY).—P/O. A. Baerlein; P/O. G. R. Bruce; Sgt. M. R. Forty; Sgt. G. L. McInerny; Sgt. J. K. Millar; Sgt. J. L. Perrin; Sgt. L. W. Rogers; Sgt. R. E. Sayer; Sgt. P. F. Tracey; Sgt. T. Varley; F/O. C. C. G. Webb.

PREVIOUSLY REPORTED MISSING, BELIEVED KILLED IN ACTION, NOW PRESUMED KILLED IN ACTION.—F/O. H. F. Auger; Sgt. A. H. Lister.

PREVIOUSLY REPORTED MISSING, NOW PRESUMED KILLED IN ACTION.—Sgt. H. T. Barrett; Sgt. P. G. V. Chanler; P/O. R. H. T. Cressy; Sgt. F. Gilby; Act. Flt. Lt. A. E. Hill; Sgt. E. I. Holland; Sgt. R. Hutchinson; P/O. W. W. McMaster; P/O. N. C. MacIver; Sgt. J. L. Montague; P/O. R. R. Morison; Sgt. W. A. Newton; Sgt. H. K. Pass; Sgt. B. G. Pitt; P/O. M. S. Proudlock; Sgt. D. R. Rawlings; Act. Sqn. Ldr. A. S. Q. Robins; Sgt. W. C. Stone; Sgt. D. H. Trotman; Sgt. G. J. W. Webb; Sgt. J. L. G. Westley; Sgt. E. J. M. Whittle; Sgt. S. A. Wilkins; Sgt. W. H. Wilkinson.

PREVIOUSLY REPORTED MISSING, NOW REPORTED KILLED IN ACTION.—Sgt. F. E. Richardson.

MISSING, BELIEVED KILLED IN ACTION.—F/O. E. S. Aldous; Sgt. J. R. Ashley; Sgt. F. E. Austin; Sgt. H. H. M. Barton; Sgt. A. E. R. Beverley; P/O. B. D. Bowes-Cavanagh; Sgt. W. H. Box; Sgt. R. G. Butt; Sgt. A. J. Carter; Sqn. Ldr. P. B. Chamberlain; Sgt. D. V. Chant; P/O. D. W. D. Faint; P/O. G. C. Frew; Sgt. J. G. Hanlin; Sgt. D. C. Holley; Sgt. T. Kelly; Sgt. J. W. Leason; Sgt. W. M. McGarry; Sgt. J. E. Medhurst; P/O. L. A. Paskell, D.F.M.; Sgt. I. H. D. Passy; Sgt. K. H. Price; Sgt. G. H. Roberts; Sgt. T. J. Snell; Sgt. G. P. Spindler; Sgt. J. C. Sprague; Sgt. R. S. Stuart; Sgt. P. B. Tomes; Sgt. E. J. Waldron; Sgt. M. C. Young.

Loading 20 mm. cannon shell drums for the Spitfire Vs. of No. 603 (City of Edinburgh) Fighter Squadron. No. 603 has 128 enemy aircraft to its credit.

MISSING.—Sgt. W. H. Anderson; P/O. I. A. N. Atchison; Sgt. R. C. Barker; Sgt. H. R. Barnett; Sgt. F. G. Barrett; Sgt. R. E. Bates; Sgt. D. I. Beney; Sgt. J. W. Bradley; Sgt. C. K. Bremner; Sgt. J. P. B. Cambray; Sgt. J. R. Carney; Sgt. L. J. Compton; Sgt. A. D. Craig; Sgt. A. R. Credland; Sgt. F. H. E. Dearden; Sgt. B. C. Dymott; Sgt. K. G. Edis; Sgt. K. P. J. Fullagar; Sgt. E. F. G. Gill; Sgt. A. H. Greenwood; Sgt. J. E. Hawkins; Sgt. J. R. Hiscock; Sgt. J. E. Horne; Sgt. G. Hudson; Sgt. A. W. Humphries; Sgt. T. Jarrett; Sgt. G. G. King; Flt. Sgt. I. J. McDonald; Sgt. C. B. McMullan; Sgt. D. W. Marshall; Sgt. J. A. Matetich; Sgt. R. J. Mountier; Sgt. F. W. Norton; Sgt. J. W. Paul; Sgt. L. T. Powles; Sgt. M. S. Preece; F/O. J. W. Renwick; Sgt. B. W. Robbens; Sgt. R. L. Robinson; P/O. J. P. Rowntree; P/O. R. G. C. Rusbridge; Sgt. A. Service; Sgt. I. A. Spence-Ross; Sgt. F. P. Stewart; Act. Sqn. Ldr. R. T. Stubbs, D.F.C.; Sgt. A. J. Thomas; P/O. G. S. Turner; Sgt. A. P. Vaisey; Sgt. C. D. G. Walter; F/O. G. Washington; Sgt. J. H. White; Sgt. B. Widdecombe; W/O. J. E. Woodward; Sgt. F. H. Worlledge.

MISSING, BELIEVED KILLED ON ACTIVE SERVICE. (WHILE ENGAGED ON NON-OPERATIONAL FLYING DUTIES OR ON THE GROUND THROUGH ENEMY ACTION.)—Sgt. L. H. Wrightson.

KILLED ON ACTIVE SERVICE.—P/O. D. B. Alan Williams; Sgt. G. L. B. Arthur; Sgt. S. B. Ashton; Sgt. A. W. Bissell; Cpl. W. A. Carr; Sgt. W. G. Chant; Sgt. L. G. Cockram; Sgt. G. B. Dundas; L.A/C. G. D. H. Edworthy; L.A/C. B. T. Evans; Sgt. F. J. Goodwin; Sgt. R. Gordon; P/O. E. R. Hamer; L.A/C. H. D. Hamilton; L.A/C. H. T. Hanley; Sgt. P. W. Harris; A/C.2 W. Hebditch; P/O. P. N. Hewitt; P/O. D. H. Hodgkison; Sgt. J. D. Hogden; Sgt. S. K. Holland; Sgt. H. Hughes; Sgt. H. E. Jacobs; Sgt. G. E. Kelly; Sgt. H. C. King; Flt. Sgt. F. C. N. Kiteley; Flt. Sgt. H. J. H. Kitson; Sgt. L. Luck; Sgt. P. J. Masini; P/O. A. D. Morris; L.A/C. A. J. Morris; P/O. B. A. H. Newton; Sgt. J. G. Nubley; P/O. J. F. Reid; Sgt. L. M. Rhodes; Sgt. V. E. T. Riddiford; Sgt. E. Robinson; Sgt. C. P. A. Rose-Innes; Sgt. C. K. Rutt; Sgt. S. E. Sales; Sgt. L. A. Saul; L.A/C. R. W. Seymour; L.A/C. F. J. P. Tapper; Sgt. J. A. Taylor; Sgt. L. H. Thackwell; Sgt. P. D. Thompson; L.A/C. C. D. Thomson; Sgt. C. B. Van Deemter; Sgt. C. H. Webb, Sgt. R. Whittington; Sgt. B. K. G. Willmer; P/O. B. Willoughby; Sgt. M. W. Wright; Sgt. J. Wright.

PREVIOUSLY REPORTED MISSING, BELIEVED KILLED ON ACTIVE SERVICE, NOW PRESUMED KILLED ON ACTIVE SERVICE.—P/O. F. S. H. Ford; Sgt. H. S. Murray; Sgt. H. C. Salt; Sgt. A. J. Turner; Sgt. G. Whittaker; Sgt. W. P. Wilkinson.

PREVIOUSLY REPORTED MISSING, NOW PRESUMED KILLED ON ACTIVE SERVICE.—F/O. F. W. Gudgeon.

WOUNDED OR INJURED ON ACTIVE SERVICE.—F/O. L. C. Boore, D.F.M.; Sgt. S. Davies; Sgt. H. S. Dunbar; P/O. R. B. Finney; P/O. W. E. Pinfold.

DIED OF WOUNDS OR INJURIES RECEIVED ON ACTIVE SERVICE.—Sgt. A. I. W. Fairburn; L.A/C. G. McDougall.

DIED ON ACTIVE SERVICE.—P/O. W. A. F. Alderton; L.A/C. L. J. Box; A/C.2 J. E. Bright; Cpl. R. Burton; A/C.2 A. W. Cooke; A/C.1 D. Gill; A/C.2 L. Henderson; A/C.1 J. Horan; Sgt. J. L. Jacobs; A/C.2 F. W. Lawson; A/C.1 L. E. K. Lax; L.A/C. D. MacMillan; F/O. E. G. Neuman; Flt. Sgt. H. A. Pechey; A/C.1 V. C. Taylor; Sgt. S. Vincent; A/C.2 E. Ward.

PREVIOUSLY REPORTED MISSING, NOW REPORTED SAFE.—Sgt. J. A. U. Quitzow.

PREVIOUSLY REPORTED MISSING, NOW REPORTED PRISONER OF WAR.—Sgt. W. C. P. Martin.

Royal Australian Air Force

MISSING, BELIEVED KILLED IN ACTION.—Sgt. W. E. Hearle.

MISSING.—Sgt. P. L. Browne; Sgt. H. D. Grimes; Sgt. H. A. A. North; Sgt. L. R. Read; Sgt. F. Richardson; Sgt. D. A. Scott.

KILLED ON ACTIVE SERVICE.—Sgt. M. H. Morgan; P/O. P. C. Nangle; P/O. R. R. Sly.

PREVIOUSLY REPORTED MISSING, BELIEVED KILLED ON ACTIVE SERVICE, NOW REPORTED KILLED ON ACTIVE SERVICE.—P/O. K. T. Little.

Royal Canadian Air Force

KILLED IN ACTION.—P/O. H. L. M. Young.

MISSING, BELIEVED KILLED IN ACTION.—Sgt. W. S. Barclay, Sgt. D. A. Cameron; Sgt. A. J. Childs; Sgt. A. H. Figg; Sgt. C. T. Harbottle; P/O. J. A. Robinson; Sgt. D. A. Rutherford; Sgt. E. A. Tredenick.

MISSING.—Sgt. D. F. Barkhouse; P/O. D. W. Brubacker; Sgt. G. L. Chapman; P/O. H. V. Hegarty, Sgt. C. J. F. McCrum; Sgt. R. M. McIntyre; Sgt. D. S. Mather; Sgt. S. I. C. Moulds; Sgt. R. G. Postans; Act. F/O. A. E. Snell; Sgt. W. P. Thom; Sgt. J. E. Weir.

KILLED ON ACTIVE SERVICE.—P/O. R. D. Anderson; P/O. J. W. Atkin; Sgt. D. H. Budden; Flt. Lt. L. R. Dubus; Sgt. B. Fullerton; Sgt. J. A. McEachern; Sgt. I. A. MacDonald; P/O. J. R. Robertson.

PREVIOUSLY REPORTED MISSING, BELIEVED KILLED ON ACTIVE SERVICE, NOW PRESUMED KILLED ON ACTIVE SERVICE.—P/O. R. B. Campbell; Sgt. L. C. Cowing; Sgt. J. A. Proctor.

Royal New Zealand Air Force

MISSING.—Sgt. J. A. Edwards; P/O. T. B. Robertson; Sgt. N. H. Welsh; Sgt. F. L. R. Wood.

KILLED ON ACTIVE SERVICE.—Sgt. G. F. Hillier; P/O. T. W. McC. Leckie; Sgt. G. J. McGill-Nutt; Sgt. L. M. G. Macdonald; P/O. B. W. Miller.

South African Air Force

KILLED IN ACTION.—Lt. P. Hedley.

MISSING.—Air Sgt. R. S. Daniels; 2/Lt. A. W. J. Frick; 2/Lt. A. Luow; Air Sgt. I. H. MacFadyn.